hnson's New

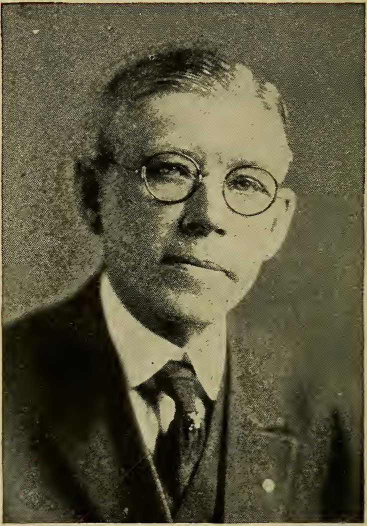
HANDY MANUAL

**PLUMBING
HEATING
VENTILATING**

and

**MECHANICAL
REFRIGERATION**

*A Practical Book
for
Practical Men*



JOHN W. JOHNSON,

Author and Publisher of "Johnson's Handy Manual" and Mechanical Engineer

Johnson John W.

JOHNSON'S NEW HANDY MANUAL

ON

PLUMBING
HEATING
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AND
MECHANICAL REFRIGERATION

TENTH EDITION

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JOHN W. JOHNSON
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Dedication

TO THE STEAM-FITTERS AND PLUMBERS

WITH WHOM I HAVE SPENT
SO MANY PLEASANT YEARS,
I DEDICATE THIS MANUAL

Aug. 11. 20.

S. T. K.

Johnson's Handy Manual.

Cross-Connected Pumps

Fig. A shows a battery of boilers with cross-connected pumps. Feed water heater and tank on the roof.

The installation is as follows:

For Suction:

Connect pumps No. 1 and No. 2, as in illustration, by 4"x3" tees to the city main. Between the tees and pump connections insert gate valves A and B and flange unions. Valve must in all cases be next to the tee so that in case either pump should have to be disconnected, valves A or B can be closed and the pump disconnected without interfering with the water supply.

From the tee, connecting pump No. 1, run a 4" pipe to a point directly under the roof tank and with a long sweep elbow continue the pipe up through the roof and connect to the bottom of the tank on this pipe, marked 4" tank suction on the illustration; at a convenient place, insert a 4x2" tee and connect with 2" pipe, marked "feed to boiler through heater," using valve C and flange union. When feed from tank direct to boilers close valve D and open valve C. When feed which has passed through the heater is wanted close valve C and open valve D. Check valve E. E. must be set to open with the flow of water from tank or heater.

Pump Discharge:

When pumping to roof tank close valves F. and G. and open valves H. and I. Check valve J. must be set to open with the flow of water to the tank.

If direct feed from pump No. 1 to boiler is wanted proceed as follows:

Close valves H., G. and L. and open valves F. and M. The flow will open check valve E and close check valve E. E. If direct feed from Pump No. 2 to boiler is wanted close valves I., F. and L. and open valves G. and M. Check valves E. and E. E. have the same action as when pump No. 1 is used.

Feed to Heater:

When using pump No. 1 to supply water to heater, close valves H., G. and M. and open valves F. and L. When pump No. 2 is used close valves I., F. and M. and open valves G. and L.

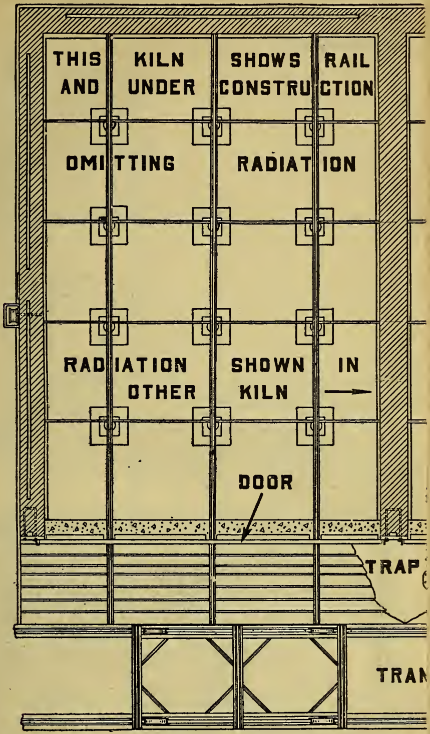
Note:

Illustration being an elevation to show all pipes, valves and unions, the position of the pipes must necessarily be somewhat extorted.

Pipes should not be higher from the floor but what a man could easily reach all valves when standing on the floor.

All valves on branches should be placed as near as possible to the supply pipe from which its duty is to stop the supply when not wanted; for instance: Valves, H. and I. with their unions should be placed as near the tees N. and O. as possible.

Steam to pumps, exhaust from pumps to heater and feed to boiler through heater are shown so plainly in the illustration that any explanation is unnecessary.



PLAN OF PAIR OF MODERN BOX DR
TO BE APPROXIMATELY 18-FT WIDE
INSIDE AND ABOVE RAIL. WILL EAC
FEET BOARD MEASURE (AN AVERAGE
LUMBER 16-FT LONG. TI
AIR SPACE IN WALL, CONCRETE FO
DOORS AND PLATFORMS.
COURTESY

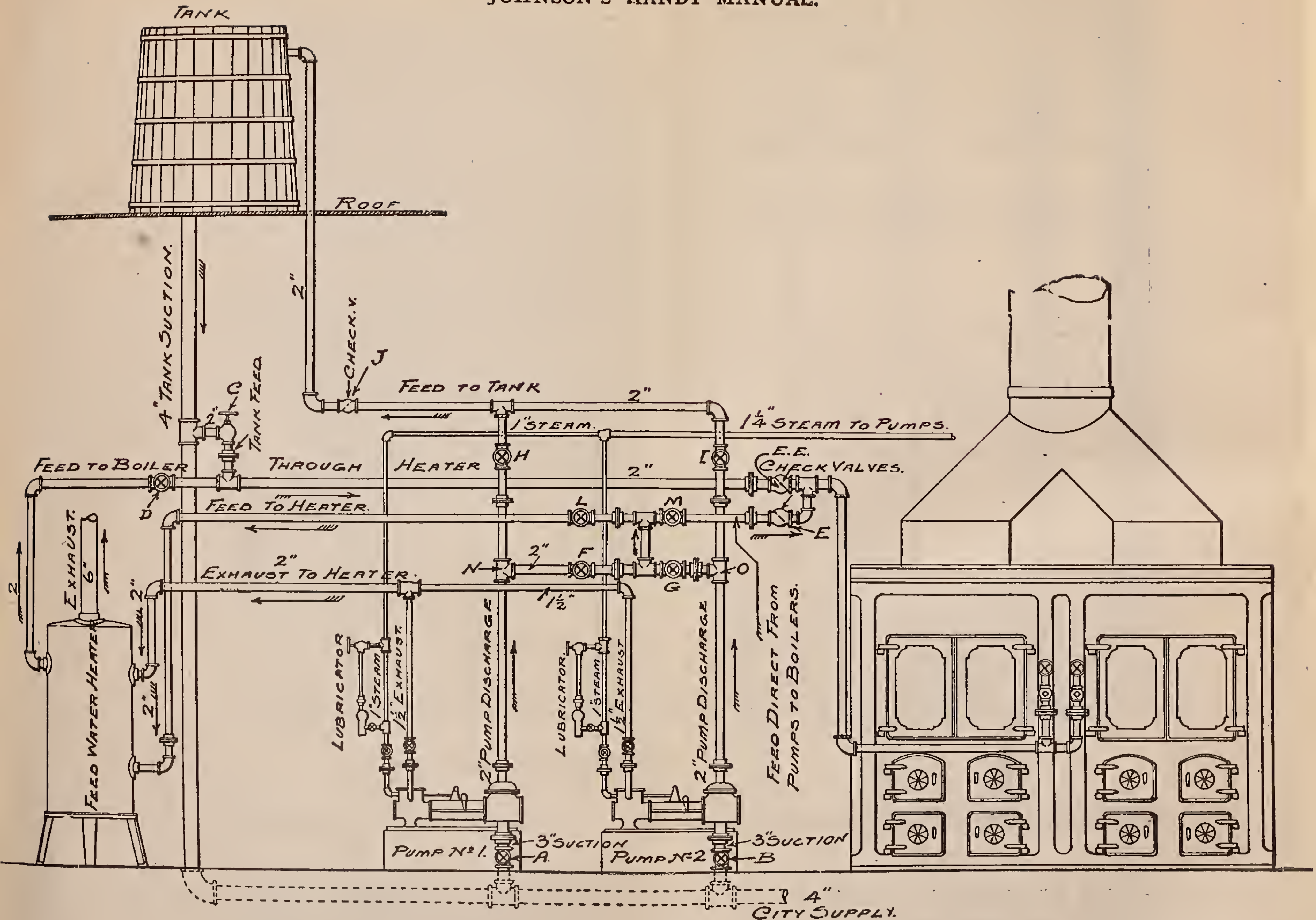
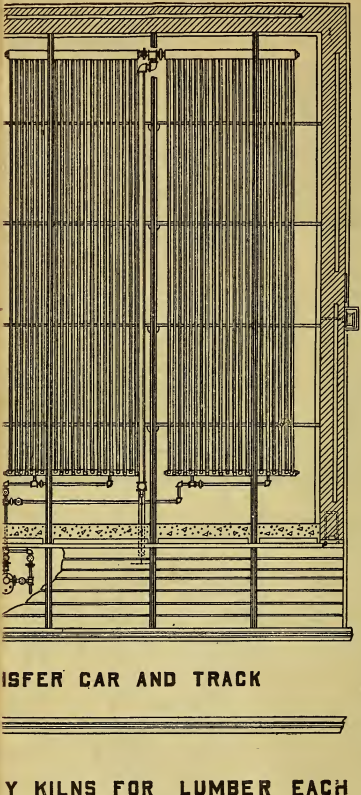

TANK
ROOF
4" TANK SUCTION.
2"
CHECK.V.
J
C
TANK FEED
FEED TO TANK
2"
1" STEAM.
1¼" STEAM TO PUMPS.
H
I
E.E.
CHECK VALVES.
FEED TO BOILER
THROUGH
HEATER
2"
D
FEED TO HEATER.
L
M
E
2"
F
N
O
G
EXHAUST TO HEATER.
1½"
EXHAUST.
6"
FEED WATER HEATER
LUBRICATOR
1" STEAM
1½" EXHAUST
2" PUMP DISCHARGE
FEED DIRECT FROM PUMPS TO BOILERS.
3" SUCTION
PUMP No 1.
A.
PUMP No 2
B
4"
CITY SUPPLY.

Fig. A



ISFER CAR AND TRACK

Y KILNS FOR LUMBER EACH
: BY 27-FT LONG 10-FT HIGH
;H HOLD APPROXIMATELY 15000
: RAILROAD CAR) OF ONE INCH
) BE ERECTED OF BRICK WITH
UNDATIONS, TILE ROOF, WOOD

(OF GRAND RAPIDS DRY KILN

Overhead System of Hot Water Heating Apparatus.

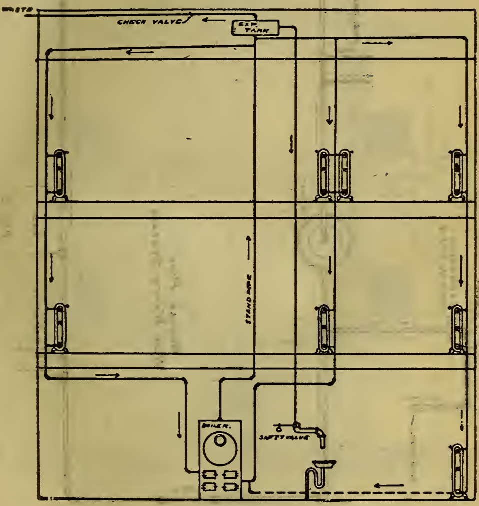
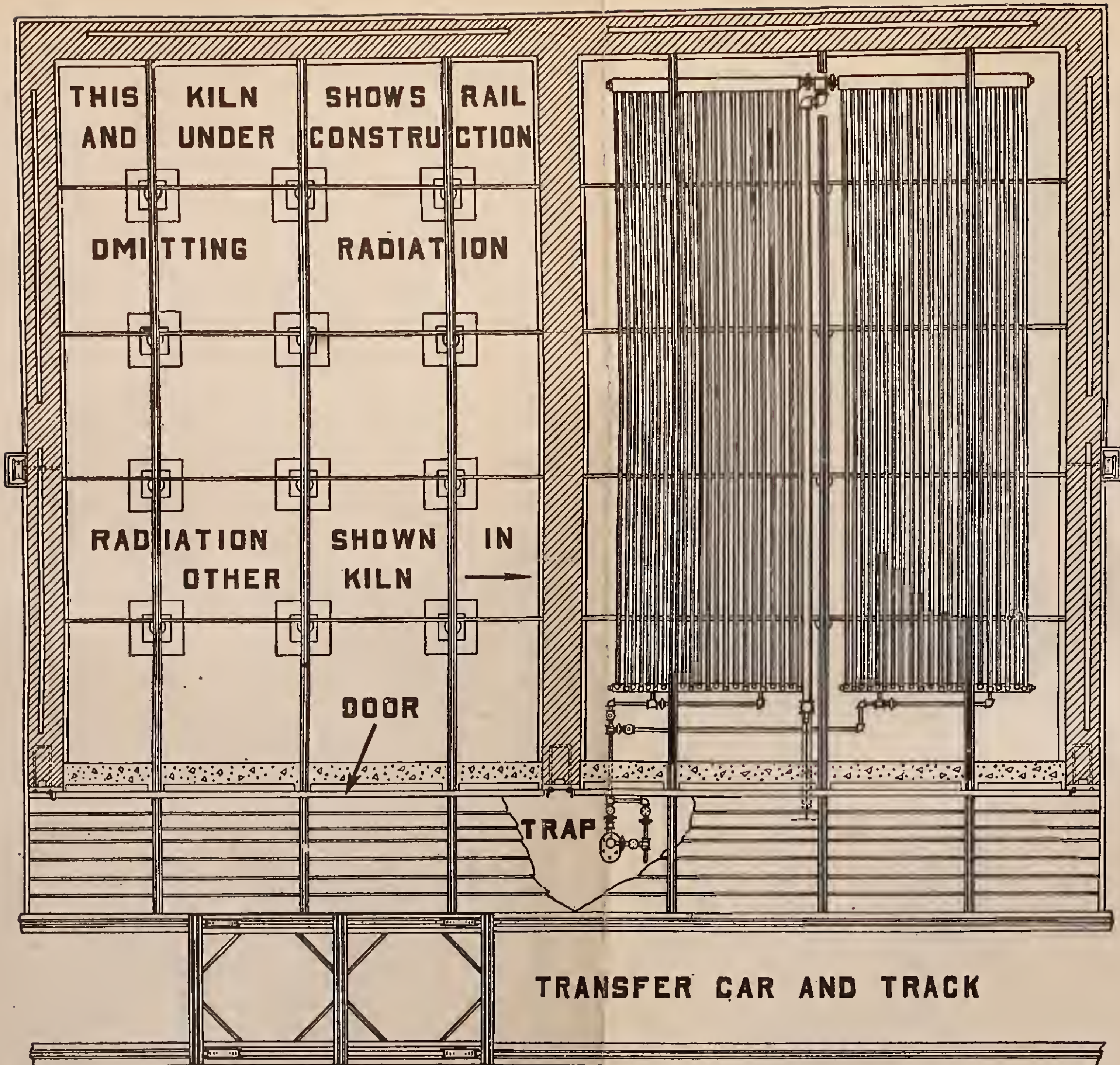


Fig. 1.



PLAN OF PAIR OF MODERN BOX DRY KILNS FOR LUMBER EACH TO BE APPROXIMATELY 16-FT WIDE BY 27-FT LONG 10-FT HIGH INSIDE AND ABOVE RAIL. WILL EACH HOLD APPROXIMATELY 15000 FEET BOARD MEASURE (AN AVERAGE RAILROAD CAR) OF ONE INCH LUMBER 16-FT LONG. TO BE ERECTED OF BRICK WITH AIR SPACE IN WALL, CONCRETE FOUNDATIONS, TILE ROOF, WOOD DOORS AND PLATFORMS.

COURTESY OF GRAND RAPIDS DRY KILN

Single Pipe Hot Water System.

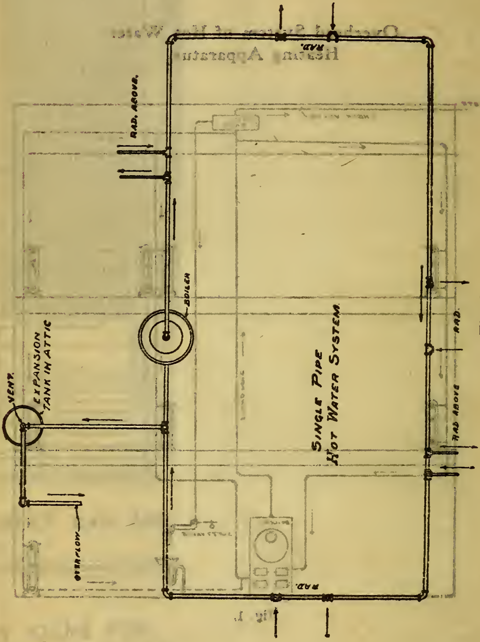


Fig. 2.

Overhead Open Hot Water System.

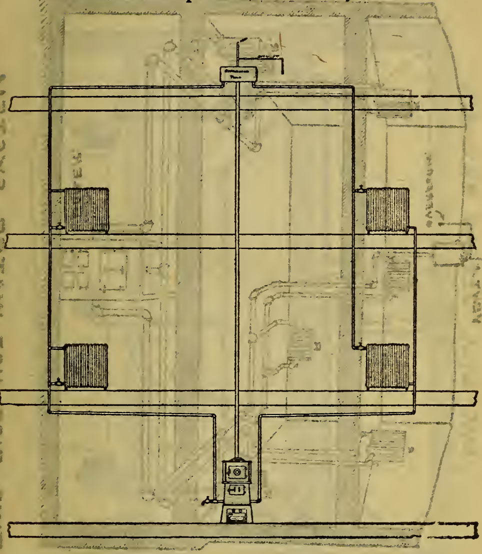
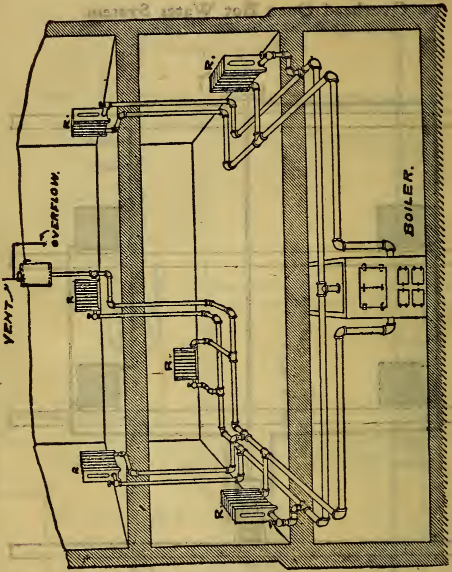
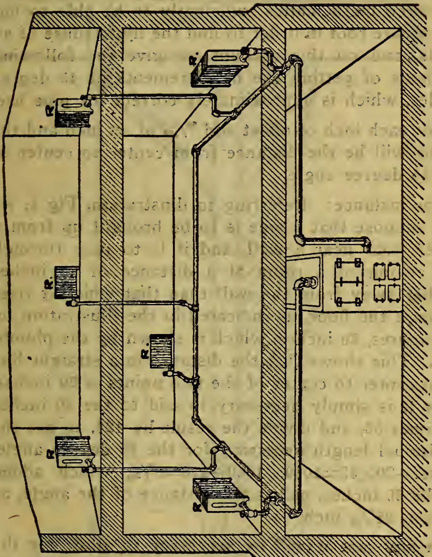


Fig. 3.



TWO PIPE HOT WATER SYSTEM.



ONE PIPE STEAM SYSTEM.

An Easy and Correct Method of Ascertaining Length of Pipe Required in 45° Angles

In the pipe fitting of steam and hot water heating plants, 45 degree elbows are brought into use extensively and it is not every mechanic who has mastered mathematics sufficiently to be able to figure square root in order to find the hypotenuse of an angle, and on this account we give the following methods of getting the measurements of 45 degree angles, which is approximately correct for pipe use.

For each inch of offset add $^{53}/_{128}$ of an inch and the result will be the distance from center to center of the 45 degree angle.

For instance: Referring to illustration, Fig 4, we will suppose that a pipe is to be brought up from a lower floor near a wall, and it is to pass through the ceiling of a room at a distance of 20 inches farther away from the wall than that which it rises through the floor, as indicated in the illustration by the figures, 20 inches, which is shown by the plumb-bob. This shows that the distance in a straight line from center to center of the two points is 20 inches. Now it is simply necessary to add to the 20 inches 20 times 53, and divide the result by 128, to get the additional length necessary for the 45 degree angle. Thus:—$20 \times 53 = 1060$, $1060 \div 128 = 8^9/_{32}$, which added to the 20 inches, makes the distance of the angle, as shown, $28^9/_{32}$ inch.

In any case it will be necessary to allow for the distance taken up by the fittings from center to center of same, as shown in Fig. 5.

By this system it will make no difference how many inches the offset may be; simply add for each inch an additional fraction of $^{53}/_{128}$ of an inch. Again, suppose the offset is to be 5 inches, we multiply 5

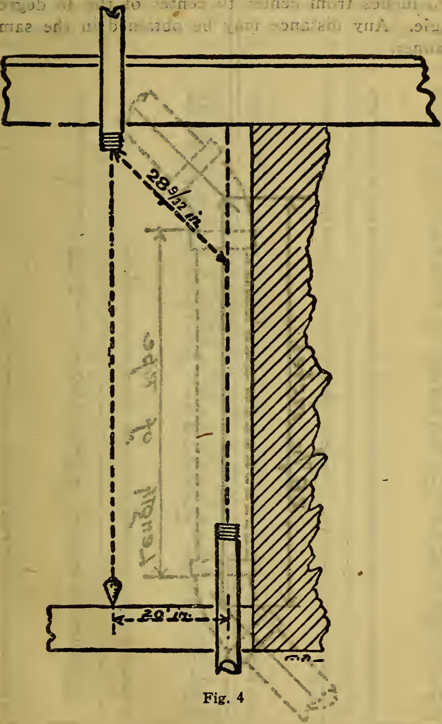


Fig. 4

by 53, which gives us 265. We now divide the 265 by 128, which gives us $2^1/_{16}$; this result we now add to 5 inches, which is the distance of offset, and we have $7^1/_{16}$ inches from center to center of the 45 degree angle. Any distance may be obtained in the same manner.

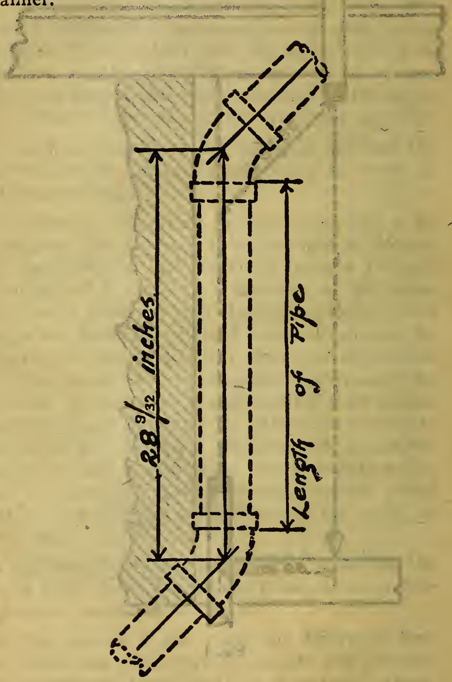


Fig. 5

Table of Diagonals for 45° Triangles Measuring from 1 Inch to 20 Feet on the Sides.

Sides. Ft.	In.	Diagonal. Ft.	In.	Sides. Ft.	In.	Diagonal. Ft.	In.
	1		1 7/16	3	1	4	4 5/16
	2		2 13/16	3	2	4	5 3/4
	3		4 1/4	3	3	4	7 3/16
	4		5 5/8	3	4	4	8 9/16
	5		7 1/16	3	5	4	10
	6		8 1/2	3	6	4	11 3/8
	7		9 7/8	3	7	5	13/16
	8		11 5/16	3	8	5	2 1/4
	9		12 3/4	3	9	5	3 5/8
	10	1	2 1/8	8	10	5	5 1/16
	11	1	3 9/16	3	11	5	6 7/16
	12	1	5	4		5	7 7/8
1	1	1	6 3/8	4	1	5	9 5/16
1	2	1	7 13/16	4	2	5	10 11/16
1	3	1	9 3/16	4	3	6	1/8
1	4	1	10 5/8	4	4	6	1 9/16
1	5	2	1/16	4	5	6	2 15/16
1	6	2	1 7/16	4	6	6	4 3/8
1	7	2	2 7/8	4	7	6	5 3/4
1	8	2	4 5/16	4	8	6	7 3/16
1	9	2	5 11/16	4	9	6	8 5/8
1	10	2	7 1/8	4	10	6	10
1	11	2	8 1/2	4	11	6	11 7/16
2		2	9 15/16	5		7	7/8
2	1	2	11 3/8	5	1	7	2 1/4
2	2	3	3/4	5	2	7	3 11/16
2	3	3	2 3/16	5	3	7	5 1/16
2	4	3	3 5/16	5	4	7	6 1/2
2	5	3	5	5	5	7	7 15/16
2	6	3	6 7/16	5	6	7	9 5/16
2	7	3	7 13/16	5	7	7	10 3/4
2	8	3	9 1/4	5	8	8	3/16
2	9	3	10 11/16	5	9	8	1 9/16
2	10	4	1/16	5	10	8	3
2	11	4	1 1/2	5	11	8	4 7/16
3		4	2 15/16	6		8	5 13/16

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals for 45° Triangles Measuring from 1 Inch to 20 Feet on the Sides.

Sides. Ft.	In.	Diagonal. Ft.	In.	Sides. Ft.	In.	Diagonal. Ft.	In.
6	1	8	7¼	9	1	12	10⅛
6	2	8	8⅝	9	2	12	11 9/16
6	3	8	10 1/16	9	3	13	1
6	4	8	11½	9	4	13	2⅜
6	5	9	⅞	9	5	13	3 13/16
6	6	9	2 5/16	9	6	13	5¼
6	7	9	3¾	9	7	13	6⅝
6	8	9	5⅛	9	8	13	8 1/16
6	9	9	6½	9	9	13	9 7/16
6	10	9	7 15/16	9	10	13	10⅞
6	11	9	9⅜	9	11	14	5/16
7		9	10 13/16	10		14	1 11/16
7	1	10	3/16	10	1	14	3⅛
7	2	10	1⅝	10	2	14	4 9/16
7	3	10	3	10	3	14	5 15/16
7	4	10	4 7/16	10	4	14	7⅜
7	5	10	5⅞	10	5	14	8¾
7	6	10	7¼	10	6	14	10 3/16
7	7	10	8 11/16	10	7	14	11⅝
7	8	10	10⅛	10	8	15	1
7	9	10	11½	10	9	15	2 7/16
7	10	11	15/16	10	10	15	3⅞
7	11	11	2⅜	10	11	15	5¼
8		11	3¾	11		15	6 11/16
8	1	11	5 3/16	11	1	15	8 1/16
8	2	11	6⅝	11	2	15	9½
8	3	11	8	11	3	15	10 15/16
8	4	11	9 7/16	11	4	16	⅜
8	5	11	10 13/16	11	5	16	1¾
8	6	12	¼	11	6	16	3 3/16
8	7	12	1 11/16	11	7	16	4 9/16
8	8	12	3 1/16	11	8	16	6
8	9	12	4½	11	9	16	7⅜
8	10	12	5⅞	11	10	16	8 13/16
8	11	12	7 5/16	11	11	16	10¼
9		12	8¾	12		16	11⅝

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals for 45° Triangles Measuring from 1 Inch to 20 Feet on the Sides.

Sides. Ft.	Sides. In.	Diagonal. Ft.	Diagonal. In.	Sides. Ft.	Sides. In.	Diagonal. Ft.	Diagonal. In.
12	1	17	1 1/16	15	1	21	4
12	2	17	2 7/16	15	2	21	5 3/8
12	3	17	3 7/8	15	3	21	6 13/16
12	4	17	5 5/16	15	4	21	8 3/16
12	5	17	6 11/16	15	5	21	9 5/8
12	6	17	8 1/8	15	6	21	11 1/16
12	7	17	9 9/16	15	7	22	7/16
12	8	17	10 15/16	15	8	22	1 7/8
12	9	18	3/8	15	9	22	3 5/16
12	10	18	11 13/16	15	10	22	4 11/16
12	11	18	3 3/16	15	11	22	6 1/8
13		18	4 5/8	16		22	7 1/2
13	1	18	6	16	1	22	8 15/16
13	2	18	7 7/16	16	2	22	10 3/8
13	3	18	8 7/8	16	3	22	11 3/4
13	4	18	10 1/4	16	4	23	1 3/16
13	5	18	11 11/16	16	5	23	2 5/8
13	6	19	1 1/8	16	6	23	4
13	7	19	2 1/2	16	7	23	5 7/16
13	8	19	3 15/16	16	8	23	6 13/16
13	9	19	5 5/16	16	9	23	8 1/4
13	10	19	6 3/4	16	10	23	9 11/16
13	11	19	8 3/16	16	11	23	11 1/16
14		19	9 9/16	17		24	1/2
14	1	19	11	17	1	24	1 15/16
14	2	20	7/16	17	2	24	3 5/16
14	3	20	1 13/16	17	3	24	4 3/4
14	4	20	3 1/4	17	4	24	6 1/8
14	5	20	4 11/16	17	5	24	7 9/16
14	6	20	6 1/16	17	6	24	9
14	7	20	7 1/2	17	7	24	10 3/8
14	8	20	8 7/8	17	8	24	11 13/16
14	9	20	10 5/16	17	9	25	1 1/4
14	10	20	11 3/4	17	10	25	2 5/8
14	11	21	1 1/8	17	11	25	4 1/16
15		21	2 9/16	18		25	5 1/2

Extreme caution must be exercised in taking off centers of fittings in these measurements.

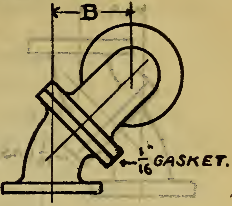
Table of Diagonals for 45° Triangles Measuring from 1 Inch to 20 Feet on the Sides.

Sides. Ft.	Sides. In.	Diagonal. Ft.	Diagonal. In.	Sides. Ft.	Sides. In.	Diagonal. Ft.	Diagonal. In.
18	1	25	6⅞	19	1	26	11⅞
18	2	25	8 5/16	19	2	27	1¼
18	3	25	9 11/16	19	3	27	2 11/16
18	4	25	11⅛	19	4	27	4 1/16
18	5	26	9/16	19	5	27	5½
18	6	26	1 15/16	19	6	27	6 15/16
18	7	26	3⅜	19	7	27	8 5/16
18	8	26	4 13/16	19	8	27	9¾
18	9	26	6 3/16	19	9	27	11 3/16
18	10	26	7⅝	19	10	28	9/16
18	11	26	9	19	11	28	2
19		26	10 7/16	20		28	3 7/16

Extreme caution must be exercised in taking off centers of fittings in these measurements.

OFFSETS

STANDARD FLGD. ELLS.



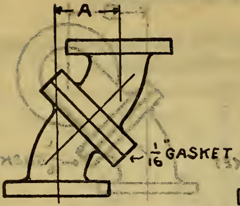
45° ELLS

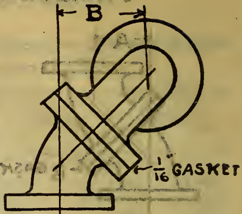
SIZE	OFFSET A
2	3 9/16
2 1/2	4 1/4
3	4 1/4
3 1/2	5
4	5 11/16
4 1/2	5 11/16
5	6 3/8
6	7 1/8
7	7 13/16
8	7 13/16
9	8 1/2
10	9 1/4
12	10 5/8
14	10 5/8
15	11 3/8
16	11 3/8
18	12 1/16
20	13 1/2
22	14 3/16
24	15 5/8

45° AND 90° ELLS.

SIZE	OFFSET B
2	5
2 1/2	5 11/16
3	6 1/16
3 1/2	6 3/4
4	7 7/16
4 1/2	7 13/16
5	8 1/2
6	9 1/4
7	9 15/16
8	10 5/16
9	11 3/8
10	12 7/16
12	13 13/16
14	15 1/4
15	15 15/16
16	16 5/16
18	17 11/16
20	19 1/2
22	21 1/4
24	23 3/8

OFFSETS.
EXTRA HEAVY FLGD. ELLS.





45° ELLS

SIZE	OFFSET A
2	4 1/4
2 1/2	5
3	5
3 1/2	5 11/16
4	6 3/8
4 1/2	6 5/8
5	7 1/8
6	7 13/16
7	8 1/2
8	8 1/2
9	9 1/4
10	9 15/16
12	11 3/8
14	11 3/8
15	12 1/16
16	12 3/4
18	13 1/2
20	14 3/16
22	14 7/8
24	16 5/16

45° AND 90° ELLS

SIZE	OFFSET B
2	5 11/16
2 1/2	6 3/8
3	6 3/4
3 1/2	7 7/16
4	8 3/16
4 1/2	8 1/2
5	9 1/4
6	9 15/16
7	10 5/8
8	11 3/8
9	12 1/16
10	13 1/8
12	14 7/8
14	15 15/16
15	16 5/8
16	17 11/16
18	18 3/4
20	20 3/16
22	21 5/8
24	23 3/4

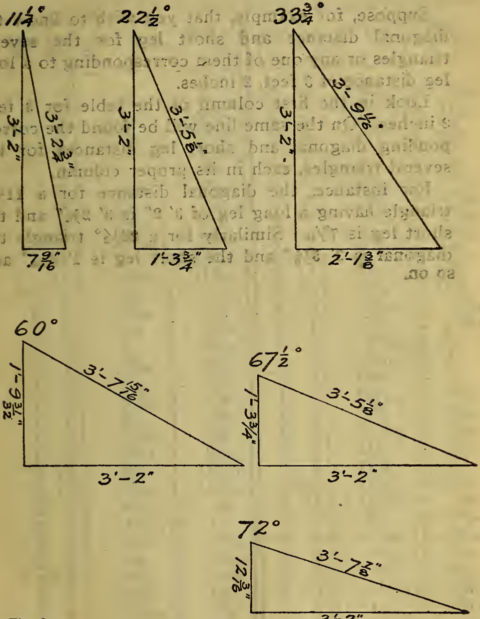

11¼°
3'-2"
3'-2¾"
7 9/16"
22½°
3'-2"
3'-5⅝"
1'-3¾"
33¾°
3'-2"
3'-9 1/16"
2'-7⅜"
60°
1'-9 31/32"
3'-7 15/16"
3'-2"
67½°
1'-3¾"
3'-5⅛"
3'-2"
72°
12 3/16"
3'-7⅞"
3'-2"

Fig. 6

Table of Long and Short Legs and Diagonals for 11¼, 22½, 33¾, 60, 67½ and 72 Degree Triangles.

As Shown in Fig. 6

Suppose, for example, that you wish to know the diagonal distance and short leg for the several triangles or any one of them corresponding to a long leg distance of 3 feet, 2 inches.

Look in the first column of the table for 3 feet, 2 inches. On the same line will be found the corresponding diagonal and short leg distances for the several triangles, each in its proper column.

For instance, the diagonal distance for a 11¼° triangle having a long leg of 3′ 2″ is 3′ 2¾″ and the short leg is 7⁹⁄₁₆. Similarly for a 22½° triangle the diagonal is 3′ 5⅛″ and the short leg is 1′ 3¾″ and so on.

Table of Diagonals for 11 1/4° Triangles Measuring from 1 Inch to 10 Feet on the Sides.

Long Leg Ft.	Long Leg In.	Sh. Leg Ft.	Sh. Leg In.	Diag. Ft.	Diag. In.	Long Leg Ft.	Long Leg In.	Sh. Leg Ft.	Sh. Leg In.	Diag. Ft.	Diag. In.
	1		3/16		1	3	0		7 3/16	3	11/16
	2		3/8		2 1/16	3	1		7 3/8	3	1 11/16
	3		5/8		3 1/16	3	2		7 9/16	3	2 3/4
	4		13/16		4 1/16	3	3		7 13/16	3	3 3/4
	5		1		5 1/8	3	4		8	3	4 3/4
	6		1 3/16		6 1/8	3	5		8 3/16	3	5 13/16
	7		1 3/8		7 1/8	3	6		8 3/8	3	6 13/16
	8		1 9/16		8 1/8	3	7		8 9/16	3	7 13/16
	9		1 13/16		9 3/16	3	8		8 3/4	3	8 13/16
	10		2		10 3/16	3	9		9	3	9 7/8
	11		2 3/16		11 3/16	3	10		9 3/16	3	10 7/8
1	0		2 3/8	1	1/4	3	11		9 3/8	3	11 7/8
1	1		2 9/16	1	1 1/4	4	0		9 9/16	4	15/16
1	2		2 3/4	1	2 5/16	4	1		9 3/4	4	1 15/16
1	3		3	1	3 5/16	4	2		9 15/16	4	3
1	4		3 3/16	1	4 5/16	4	3		10 3/16	4	4
1	5		3 3/8	1	5 3/8	4	4		10 3/8	4	5
1	6		3 9/16	1	6 3/8	4	5		10 9/16	4	6 1/16
1	7		3 3/4	1	7 3/8	4	6		10 3/4	4	7 1/16
1	8		3 15/16	1	8 3/8	4	7		10 15/16	4	8 1/16
1	9		4 3/16	1	9 7/16	4	8		11 1/8	4	9 1/16
1	10		4 3/8	1	10 7/16	4	9		11 3/8	4	10 1/8
1	11		4 9/16	1	11 7/16	4	10		11 5/8	4	11 1/8
2	0		4 3/4	2	1/2	4	11		11 13/16	5	1/8
2	1		4 15/16	2	1 1/2	5	0	1	0	5	1 3/16
2	2		5 1/8	2	2 9/16	5	1	1	3/16	5	2 3/16
2	3		5 3/8	2	3 9/16	5	2	1	3/8	5	3 1/4
2	4		5 9/16	2	4 9/16	5	3	1	5/8	5	4 1/4
2	5		5 3/4	2	5 5/8	5	4	1	13/16	5	5 1/4
2	6		5 15/16	2	6 5/8	5	5	1	1	5	6 5/16
2	7		6 1/8	2	7 5/8	5	6	1	1 3/16	5	7 5/16
2	8		6 5/16	2	8 5/8	5	7	1	1 3/8	5	8 5/16
2	9		6 9/16	2	9 11/16	5	8	1	1 9/16	5	9 5/16
2	10		6 3/4	2	10 11/16	5	9	1	1 3/4	5	10 3/8
2	11		6 15/16	2	11 11/16	5	10	1	1 15/16	5	11 3/8

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals for 11¼° Triangles Measuring from 1 Inch to 10 Feet on the Sides.

Long Leg Ft.	Long Leg In.	Sh. Leg Ft.	Sh. Leg In.	Diag. Ft.	Diag. In.	Long Leg Ft.	Long Leg In.	Sh. Leg Ft.	Sh. Leg In.	Diag. Ft.	Diag. In.
5	11	1	2⅛	6	⅜	8	0	1	7 1/16	8	1⅞
6	0	1	2 5/16	6	1 7/16	8	1	1	7¼	8	2⅞
6	1	1	2½	6	2 7/16	8	2	1	7 7/16	8	3 15/16
6	2	1	2 11/16	6	3½	8	3	1	7 11/16	8	4 15/16
6	3	1	2 15/16	6	4½	8	4	1	7⅞	8	5 15/16
6	4	1	2⅛	6	5½	8	5	1	8 1/16	8	7
6	5	1	3 5/16	6	6½	8	6	1	8¼	8	8
6	6	1	3½	6	7½	8	7	1	8 7/16	8	9
6	7	1	3 11/16	6	8½	8	8	1	8⅝	8	10
6	8	1	3⅞	6	9½	8	9	1	8⅞	8	11 1/16
6	9	1	4⅛	6	10⅝	8	10	1	9 1/16	9	1/16
6	10	1	4 5/16	6	11⅝	8	11	1	9¼	9	1 1/16
6	11	1	4½	7	⅝	9	0	1	9½	9	2⅛
7	0	1	4 11/16	7	1⅝	9	1	1	9 11/16	9	3⅛
7	1	1	4⅞	7	2⅝	9	2	1	9⅞	9	4⅛
7	2	1	5 1/16	7	3 11/16	9	3	1	10⅛	9	5 3/16
7	3	1	5 5/16	7	4 11/16	9	4	1	10 5/16	9	6 3/16
7	4	1	5½	7	5 11/16	9	5	1	10½	9	7 3/16
7	5	1	5 11/16	7	6¾	9	6	1	10 11/16	9	8¼
7	6	1	5⅞	7	7¾	9	7	1	10⅞	9	9¼
7	7	1	6 1/16	7	8¾	9	8	1	11 1/16	9	10¼
7	8	1	6¼	7	9¾	9	9	1	11¼	9	11 5/16
7	9	1	6½	7	10 13/16	9	10	1	11 7/16	10	5/16
7	10	1	6 11/16	7	11 13/16	9	11	1	11⅝	10	1 5/16
7	11	1	6⅞	8	13/16	10	0	1	11 13/16	10	2⅜

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals for 22½° Triangles Measuring from 1 Inch to 10 Feet on the Sides.

Long Leg Ft.	Long Leg In.	Short Leg Ft.	Short Leg In.	Diagonal Ft.	Diagonal In.	Long Leg Ft.	Long Leg In.	Short Leg Ft.	Short Leg In.	Diagonal Ft.	Diagonal In.
	1		7/16		1 1/16	3	1	1	3 5/16	3	4 1/16
	2		13/16		2 3/16	3	2	1	3 3/4	3	5 1/8
	3		1 1/4		3 1/4	3	3	1	4 1/8	3	6 3/16
	4		1 11/16		4 5/16	3	4	1	4 9/16	3	7 5/16
	5		2 1/16		5 7/16	3	5	1	5	3	8 3/8
	6		2 1/2		6 1/2	3	6	1	5 3/8	3	9 7/16
	7		2 7/8		7 9/16	3	7	1	5 13/16	3	10 9/16
	8		3 5/16		8 11/16	3	8	1	6 1/4	3	11 5/8
	9		3 3/4		9 3/4	3	9	1	6 5/8	4	11/16
	10		4 1/8		10 13/16	3	10	1	7 1/16	4	1 13/16
	11		4 9/16		11 7/8	3	11	1	7 7/16	4	2 7/8
1	0		5	1	1	4	0	1	7 7/8	4	3 15/16
1	1		5 3/8	1	2 1/16	4	1	1	8 5/16	4	5 1/16
1	2		5 13/16	1	3 1/8	4	2	1	8 11/16	4	6 1/8
1	3		6 1/4	1	4 1/4	4	3	1	9 1/8	4	7 3/16
1	4		6 11/16	1	5 5/16	4	4	1	9 9/16	4	8 5/16
1	5		7 1/16	1	6 3/8	4	5	1	9 15/16	4	9 3/8
1	6		7 1/2	1	7 1/2	4	6	1	10 3/8	4	10 7/16
1	7		7 7/8	1	8 9/16	4	7	1	10 3/4	4	11 1/2
1	8		8 5/16	1	9 5/8	4	8	1	11 3/16	5	5/8
1	9		8 3/4	1	10 3/4	4	9	1	11 5/8	5	1 11/16
1	10		9 1/8	1	11 13/16	4	10	2	0	5	2 3/4
1	11		9 9/16	2	7/8	4	11	2	7/16	5	3 7/8
2	0		9 15/16	2	2	5	0	2	7/8	5	4 15/16
2	1		10 3/8	2	3 1/16	5	1	2	1 1/4	5	6
2	2		10 3/4	2	4 1/8	5	2	2	1 11/16	5	7 1/8
2	3		11 3/16	2	5 1/4	5	3	2	2 1/8	5	8 3/16
2	4		11 5/8	2	6 5/16	5	4	2	2 1/2	5	9 1/4
2	5	1	0	2	7 3/8	5	5	2	2 15/16	5	10 3/8
2	6	1	7/16	2	8 1/2	5	6	2	3 5/16	5	11 7/16
2	7	1	13/16	2	9 9/16	5	7	2	3 3/4	6	1/2
2	8	1	1 1/4	2	10 5/8	5	8	2	4 3/16	6	1 5/8
2	9	1	1 11/16	2	11 11/16	5	9	2	4 9/16	6	2 11/16
2	10	1	2 1/16	3	13/16	5	10	2	5	6	3 3/4
2	11	1	2 1/2	3	1 7/8	5	11	2	5 3/8	6	4 7/8
3	0	1	2 15/16	3	2 15/16	6	0	2	5 13/16	6	5 15/16

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals for 22½° Triangles Measuring from 1 Inch to 10 Feet on the Sides.

Long Leg Ft.	Long Leg In.	Short Leg Ft.	Short Leg In.	Diagonal Ft.	Diagonal In.	Long Leg Ft.	Long Leg In.	Short Leg Ft.	Short Leg In.	Diagonal Ft.	Diagonal In.
6	1	2	6 1/4	6	7	8	1	3	4 3/16	8	9
6	2	2	6 5/8	6	8 1/8	8	2	3	4 9/16	8	10 1/16
6	3	2	7 1/16	6	9 3/16	8	3	3	5	8	11 1/8
6	4	2	7 1/2	6	10 1/4	8	4	3	5 7/16	9	1/4
6	5	2	7 7/8	6	11 3/8	8	5	3	5 13/16	9	1 5/16
6	6	2	8 5/16	7	7/16	8	6	3	6 1/4	9	2 3/8
6	7	2	8 3/4	7	1 1/2	8	7	3	6 11/16	9	3 1/2
6	8	2	9 1/8	7	2 5/8	8	8	3	7 1/16	9	4 9/16
6	9	2	9 9/16	7	3 11/16	8	9	3	7 1/2	9	5 5/8
6	10	2	9 15/16	7	4 3/4	8	10	3	7 7/8	9	6 3/4
6	11	2	10 3/8	7	5 13/16	8	11	3	8 5/16	9	7 13/16
7	0	2	10 13/16	7	6 15/16	9	0	3	8 3/4	9	8 7/8
7	1	2	11 3/16	7	8	9	1	3	9 1/8	9	10
7	2	2	11 5/8	7	9 1/16	9	2	3	9 9/16	9	11 1/16
7	3	3	1/16	7	10 3/16	9	3	3	10	10	1/8
7	4	3	7/16	7	11 1/4	9	4	3	10 3/8	10	1 1/4
7	5	3	7/8	8	5/16	9	5	3	10 13/16	10	2 5/16
7	6	3	1 1/4	8	1 7/16	9	6	3	11 1/4	10	3 3/8
7	7	3	1 11/16	8	2 1/2	9	7	3	11 5/8	10	4 1/2
7	8	3	2 1/8	8	3 9/16	9	8	4	1/16	10	5 9/16
7	9	3	2 1/2	8	4 11/16	9	9	4	7/16	10	6 5/8
7	10	3	2 15/16	8	5 3/4	9	10	4	7/8	10	7 3/4
7	11	3	3 3/8	8	6 13/16	9	11	4	1 5/16	10	8 13/16
8	0	3	3 3/4	8	7 15/16	10	0	4	1 11/16	10	9 7/8

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals of 33¾° Triangles Measuring from 1 Inch to 10 Feet on the Sides.

Long Leg Ft.	Long Leg In.	Short Leg Ft.	Short Leg In.	Diagonal Ft.	Diagonal In.	Long Leg Ft.	Long Leg In.	Short Leg Ft.	Short Leg In.	Diagonal Ft.	Diagonal In.
	1		11/16		13/16	3	1	2	3/4	3	8 1/2
	2		1 5/16		2 3/8	3	2	2	1 3/8	3	9 11/16
	3		2		3 5/8	3	3	2	2 1/16	3	10 7/8
	4		2 11/16		4 13/16	3	4	2	2 3/4	4	1/8
	5		3 5/16		6	3	5	2	3 3/8	4	1 5/16
	6		4		7 3/16	3	6	2	4 1/16	4	2 1/2
	7		4 11/16		8 7/16	3	7	2	4 3/4	4	3 11/16
	8		5 3/8		9 5/8	3	8	2	5 3/8	4	4 15/16
	9		6		10 13/16	3	9	2	6 1/16	4	6 1/8
	10		6 11/16	1	0	3	10	2	6 3/4	4	7 5/16
	11		7 3/8	1	1 1/4	3	11	2	7 3/8	4	8 1/2
1	0		8	1	2 7/16	4	0	2	8 1/16	4	9 3/4
1	1		8 11/16	1	3 5/8	4	1	2	8 3/4	4	10 15/16
1	2		9 3/8	1	4 13/16	4	2	2	9 3/8	5	1/8
1	3		10	1	6 1/16	4	3	2	10 1/16	5	1 5/16
1	4		10 11/16	1	7 1/2	4	4	2	10 3/4	5	2 9/16
1	5		11 3/8	1	8 7/16	4	5	2	11 7/16	5	3 3/4
1	6	1	0	1	9 5/8	4	6	3	1/16	5	4 15/16
1	7	1	11/16	1	10 7/8	4	7	3	3/4	5	6 1/8
1	8	1	1 3/8	2	1/16	4	8	3	1 7/16	5	7 3/8
1	9	1	2	2	1 1/4	4	9	3	2 1/16	5	8 9/16
1	10	1	2 11/16	2	2 7/16	4	10	3	2 3/4	5	9 3/4
1	11	1	3 3/8	2	3 11/16	4	11	3	3 7/16	5	10 15/16
2	0	1	4 1/16	2	4 7/8	5	0	3	4 1/16	6	3/16
2	1	1	4 11/16	2	6 1/16	5	1	3	4 3/4	6	1 3/8
2	2	1	5 3/8	2	7 1/4	5	2	3	5 7/16	6	2 9/16
2	3	1	6 1/16	2	8 1/2	5	3	3	6 1/8	6	3 3/4
2	4	1	6 11/16	2	9 11/16	5	4	3	6 3/4	6	5
2	5	1	7 3/8	2	10 7/8	5	5	3	7 7/16	6	6 3/16
2	6	1	8 1/16	3	1/16	5	6	3	8 1/8	6	7 3/8
2	7	1	8 11/16	3	1 1/8	5	7	3	8 3/4	6	8 9/16
2	8	1	9 3/8	3	2 1/2	5	8	3	9 7/16	6	9 13/16
2	9	1	10 1/16	3	3 11/16	5	9	3	10 1/8	6	11
2	10	1	10 11/16	3	4 7/8	5	10	3	10 3/4	7	3/16
2	11	1	11 3/8	3	6 1/8	5	11	3	11 7/16	7	1 3/8
3	0	2	1/16	3	7 5/16	6	0	4	1/8	7	2 5/8

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals of 33¾° Triangles Measuring from 1 Inch to 10 Feet on the Sides.

Long Leg Ft.	Long Leg In.	Short Leg. Ft.	Short Leg. In.	Diagonal Ft.	Diagonal In.	Long Leg Ft.	Long Leg In.	Short Leg. Ft.	Short Leg. In.	Diagonal Ft.	Diagonal In.
6	1	4	¾	7	3 13/16	8	1	5	4 13/16	9	8 11/16
6	2	4	1 7/16	7	5	8	2	5	5½	9	9⅞
6	3	4	2⅛	7	6 13/16	8	3	5	6⅛	9	11 1/16
6	4	4	2 13/16	7	7⅜	8	4	5	6 13/16	10	¼
6	5	4	3 7/16	7	8⅝	8	5	5	7½	10	1½
6	6	4	4⅛	7	9 13/16	8	6	5	8⅛	10	2 11/16
6	7	4	4 13/16	7	11	8	7	5	8 13/16	10	3⅞
6	8	4	5 7/16	8	3/16	8	8	5	9½	10	5 1/16
6	9	4	6⅛	8	1 7/16	8	9	5	10 3/16	10	6 5/16
6	10	4	6 13/16	8	2⅝	8	10	5	10 13/16	10	7½
6	11	4	7 7/16	8	3 13/16	8	11	5	11½	10	8 11/16
7	0	4	8⅛	8	5	9	0	6	3/16	10	9⅞
7	1	4	8 13/16	8	6¼	9	1	6	13/16	10	11 1/16
7	2	4	9 7/16	8	7 7/16	9	2	6	1½	11	5/16
7	3	4	10⅛	8	8⅝	9	3	6	2 3/16	11	1½
7	4	4	10 13/16	8	9 13/16	9	4	6	2 13/16	11	2 11/16
7	5	4	11 7/16	8	11 1/16	9	5	6	3½	11	3⅞
7	6	5	⅛	9	¼	9	6	6	4 3/16	11	5⅛
7	7	5	13/16	9	1 7/16	9	7	6	4 13/16	11	6 5/16
7	8	5	1½	9	2⅝	9	8	6	5½	11	7½
7	9	5	2⅛	9	3⅞	9	9	6	6 3/16	11	8 11/16
7	10	5	2 13/16	9	5 1/16	9	10	6	6⅞	11	9 15/16
7	11	5	3½	9	6¼	9	11	6	7½	11	11⅛
8	0	5	4⅛	9	7 7/16	10	0	6	8 3/16	12	5/16

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals of 67 1/2° Triangles Measuring from 1 Inch to 10 Feet on the Sides.

Long Leg Ft	Long Leg In.	Short Leg Ft.	Short Leg In.	Diagonal Ft.	Diagonal In.	Long Leg Ft.	Long Leg In.	Short Leg Ft.	Short Leg In.	Diagonal Ft.	Diagonal In.
	1		7/16		1 1/16	3	1	1	3 5/16	3	4 1/16
	2		13/16		2 3/16	3	2	1	3 3/4	3	5 1/8
	3		1 1/4		3 1/4	3	3	1	4 1/8	3	6 3/16
	4		1 11/16		4 5/16	3	4	1	4 9/16	3	7 5/16
	5		2 1/16		5 7/16	3	5	1	5	3	8 3/8
	6		2 1/2		6 1/2	3	6	1	5 3/8	3	9 7/16
	7		2 7/8		7 9/16	3	7	1	5 13/16	3	10 9/16
	8		3 5/16		8 11/16	3	8	1	6 1/4	3	11 5/8
	9		3 3/4		9 3/4	3	9	1	6 5/8	4	11/16
	10		4 1/8		10 13/16	3	10	1	7 1/16	4	1 13/16
	11		4 9/16		11 7/8	3	11	1	7 7/16	4	2 7/8
1	0		5	1	1	4	0	1	7 7/8	4	3 15/16
1	1		5 3/8	1	2 1/16	4	1	1	8 5/16	4	5 1/16
1	2		5 13/16	1	3 1/8	4	2	1	8 11/16	4	6 1/8
1	3		6 1/4	1	4 1/4	4	3	1	9 1/8	4	7 3/16
1	4		6 11/16	1	5 5/16	4	4	1	9 9/16	4	8 5/16
1	5		7 1/16	1	6 3/8	4	5	1	9 15/16	4	9 3/8
1	6		7 1/2	1	7 1/2	4	6	1	10 3/8	4	10 7/16
1	7		7 7/8	1	8 9/16	4	7	1	10 3/4	4	11 1/2
1	8		8 5/16	1	9 5/8	4	8	1	11 3/16	5	5/8
1	9		8 3/4	1	10 3/4	4	9	1	11 5/8	5	1 11/16
1	10		9 1/8	1	11 13/16	4	10	2	0	5	2 3/4
1	11		9 9/16	2	7/8	4	11	2	7/16	5	3 7/8
2	0		9 15/16	2	2	5	0	2	7/8	5	4 15/16
2	1		10 3/8	2	3 1/16	5	1	2	1 1/4	5	6
2	2		10 3/4	2	4 1/8	5	2	2	1 11/16	5	7 1/8
2	3		11 3/16	2	5 1/4	5	3	2	2 1/8	5	8 3/16
2	4		11 5/8	2	6 5/16	5	4	2	2 1/2	5	9 1/4
2	5	1	0	2	7 3/8	5	5	2	2 15/16	5	10 3/8
2	6	1	7/16	2	8 1/2	5	6	2	3 5/16	5	11 7/16
2	7	1	13/16	2	9 9/16	5	7	2	3 3/4	6	1/2
2	8	1	1 1/4	2	10 5/8	5	8	2	4 3/16	6	1 5/8
2	9	1	1 11/16	2	11 11/16	5	9	2	4 9/16	6	2 11/16
2	10	1	2 1/16	3	13/16	5	10	2	5	6	3 3/4
2	11	1	2 1/2	3	1 7/8	5	11	2	5 3/8	6	4 7/8
3	0	1	2 15/16	3	2 15/16	6	0	2	5 13/16	6	5 15/16

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals of 67½° Triangles Measuring from 1 Inch to 10 Feet on the Sides.

Long Leg Ft.	In.	Short Leg. Ft.	In.	Diagonal. Ft.	In.	Long Leg Ft.	In.	Short Leg. Ft.	In.	Diagonal. Ft.	In.
6	1	2	6¼	6	7	8	1	3	4³⁄₁₆	8	9
6	2	2	6⅝	6	8⅛	8	2	3	4⁹⁄₁₆	8	10¹⁄₁₆
6	3	2	7¹⁄₁₆	6	9³⁄₁₆	8	3	3	5	8	11⅛
6	4	2	7½	6	10¼	8	4	3	5⁷⁄₁₆	9	¼
6	5	2	7⅞	6	11⅜	8	5	3	5¹³⁄₁₆	9	1⁵⁄₁₆
6	6	2	8⁵⁄₁₆	7	⁷⁄₁₆	8	6	3	6¼	9	2⅜
6	7	2	8¾	7	1½	8	7	3	6¹¹⁄₁₆	9	3½
6	8	2	9⅛	7	2⅝	8	8	3	7¹⁄₁₆	9	4⁹⁄₁₆
6	9	2	9⁹⁄₁₆	7	3¹¹⁄₁₆	8	9	3	7½	9	5⅝
6	10	2	9¹⁵⁄₁₆	7	4¾	8	10	3	7⅞	9	6¾
6	11	2	10⅜	7	5¹³⁄₁₆	8	11	3	8⁵⁄₁₆	9	7¹³⁄₁₆
7	0	2	10¹³⁄₁₆	7	6¹⁵⁄₁₆	9	0	3	8¾	9	8⅞
7	1	2	11³⁄₁₆	7	8	9	1	3	9⅛	9	10
7	2	2	11⅝	7	9¹⁄₁₆	9	2	3	9⁹⁄₁₆	9	11¹⁄₁₆
7	3	3	¹⁄₁₆	7	10³⁄₁₆	9	3	3	10	10	⅛
7	4	3	⁷⁄₁₆	7	11¼	9	4	3	10⅜	10	1¼
7	5	3	⅞	8	⁵⁄₁₆	9	5	3	10¹³⁄₁₆	10	2⁵⁄₁₆
7	6	3	1¼	8	1⁷⁄₁₆	9	6	3	11¼	10	3⅜
7	7	3	1¹¹⁄₁₆	8	2½	9	7	3	11⅝	10	4½
7	8	3	2⅛	8	3⁹⁄₁₆	9	8	4	¹⁄₁₆	10	5⁹⁄₁₆
7	9	3	2½	8	4¹¹⁄₁₆	9	9	4	⁷⁄₁₆	10	6⅝
7	10	3	2¹⁵⁄₁₆	8	5¾	9	10	4	⅞	10	7¾
7	11	3	3⅜	8	6¹³⁄₁₆	9	11	4	1⁵⁄₁₆	10	8¹³⁄₁₆
8	0	3	3¾	8	7¹⁵⁄₁₆	10	0	4	1¹¹⁄₁₆	10	9⅞

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals of 60° Triangles Measuring from 1 Inch to 10 Feet on the Sides.

Long Leg Ft. In.	Short Leg Ft. In.	Diagonal Ft. In.	Long Leg Ft. In.	Short Leg Ft. In.	Diagonal, Ft. In.
1″	9/16″	1 1/8″	3′ 1″	1′ 9 3/8″	3′ 6 3/4″
2″	1 1/8″	2 5/16″	3′ 2″	1′ 9 15/16″	3′ 7 7/8″
3″	1 3/4″	3 7/16″	3′ 3″	1′ 10 1/2″	3′ 9″
4″	2 5/16″	4 5/8″	3′ 4″	1′ 11 1/16″	3′ 10 3/16″
5″	2 3/4″	5 3/4″	3′ 5″	1′ 11 11/16″	3′ 11 5/16″
6″	3 7/16″	6 15/16″	3′ 6″	2′ 1/4″	4′ 1/2″
7″	4 1/16″	8 1/16″	3′ 7″	2′ 13/16″	4′ 1 11/16″
8″	4 5/8″	9 1/4″	3′ 8″	2′ 1 3/8″	4′ 2 13/16″
9″	5 3/16″	10 3/8″	3′ 9″	2′ 2″	4′ 3 15/16″
10″	5 3/4″	11 9/16″	3′ 10″	2′ 2 9/16″	4′ 5 1/8″
11″	6 3/8″	12 11/16″	3′ 11″	2′ 3 1/8″	4′ 6 1/4″
12″	6 15/16″	13 13/16″	4′ 0″	2′ 3 11/16″	4′ 7 7/16″
1′ 1″	7 1/2″	1′ 3″	4′ 1″	2′ 4 1/4″	4′ 8 9/16″
1′ 2″	8 1/16″	1′ 4 3/16″	4′ 2″	2′ 4 7/8″	4′ 9 3/4″
1′ 3″	8 11/16″	1′ 5 5/16″	4′ 3″	2′ 5 7/16″	4′ 10 7/8″
1′ 4″	9 1/4″	1′ 6 1/2″	4′ 4″	2′ 6″	5′ 0″
1′ 5″	9 13/16″	1′ 7 5/8″	4′ 5″	2′ 6 5/8″	5′ 1 3/16″
1′ 6″	10 3/8″	1′ 8 3/4″	4′ 6″	2′ 7 3/16″	5′ 2 5/16″
1′ 7″	11″	1′ 9 15/16″	4′ 7″	2′ 7 3/4″	5′ 3 1/2″
1′ 8″	11 9/16″	1′ 11 1/16″	4′ 8″	2′ 8 5/16″	5′ 4 5/8″
1′ 9″	12 1/8″	2′ 1/4″	4′ 9″	2′ 8 7/8″	5′ 5 13/16″
1′ 10″	12 11/16″	2′ 1 3/8″	4′ 10″	2′ 9 1/2″	5′ 6 15/16″
1′ 11″	13 1/4″	2′ 2 9/16″	4′ 11″	2′ 10 1/16″	5′ 8 1/8″
2′ 0″	13 7/8″	2′ 3 11/16″	5′ 0″	2′ 10 5/8″	5′ 9 1/2″
2′ 1″	1′ 2 7/16″	2′ 4 7/8″	5′ 1″	2′ 11 1/4″	5′ 10 1/4″
2′ 2″	1′ 3″	2′ 6″	5′ 2″	2′ 11 13/16″	5′ 11 9/16″
2′ 3″	1′ 3 9/16″	2′ 7 3/16″	5′ 3″	3′ 3/8″	6′ 3/4″
2′ 4″	1′ 4 3/16″	2′ 8 5/16″	5′ 4″	3′ 15/16″	6′ 1 7/8″
2′ 5″	1′ 4 3/4″	2′ 9 1/2″	5′ 5″	3′ 1 1/2″	6′ 3 1/16″
2′ 6″	1′ 5 5/16″	2′ 10 5/8″	5′ 6″	3′ 2 1/8″	6′ 4 3/16″
2′ 7″	1′ 5 7/8″	2′ 11 13/16″	5′ 7″	3′ 2 11/16″	6′ 5 3/8″
2′ 8″	1′ 6 1/2″	3′ 15/16″	5′ 8″	3′ 3 1/4″	6′ 6 1/2″
2′ 9″	1′ 7 1/16″	3′ 2 1/8″	5′ 9″	3′ 3 13/16″	6′ 7 11/16″
2′ 10″	1′ 7 5/8″	3′ 3 1/4″	5′ 10″	3′ 4 7/16″	6′ 8 13/16″
2′ 11″	1′ 8 3/16″	3′ 4 7/16	5′ 11″	3′ 5″	6′ 10″
3′ 0″	1′ 8 3/4″	3′ 5 9/16	6′ 0″	3′ 5 9/16″	6′ 11 1/8″

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals of 60° Triangles Measuring from 1 Inch to 10 Feet on the Sides.

Long Leg Ft. In.	Short Leg Ft. In.	Diagonal Ft. In.	Long Leg Ft. In.	Short Leg Ft. In.	Diagonal Ft. In.
6′ 1″	3′ 6 1/8″	7′ 1/4″	8′ 1″	4′ 8″	9′ 4″
6′ 2″	3′ 6 3/4″	7′ 1 7/16″	8′ 2″	4′ 8 9/16″	9′ 5 1/8″
6′ 3″	3′ 7 5/16″	7′ 2 9/16″	8′ 3″	4′ 9 1/8″	9′ 6 5/16″
6′ 4″	3′ 7 7/8″	7′ 3 3/4″	8′ 4″	4′ 9 3/4″	9′ 7 7/16″
6′ 5″	3′ 8 7/16″	7′ 4 7/8″	8′ 5″	4′ 10 5/16″	9′ 8 5/8″
6′ 6″	3′ 9″	7′ 6 1/16″	8′ 6″	4′ 10 7/8″	9′ 9 3/4″
6′ 7″	3′ 9 5/8″	7′ 7 3/16″	8′ 7″	4′ 11 7/16″	9′ 10 15/16″
6′ 8″	3′ 10 3/16″	7′ 8 3/8″	8′ 8″	5′ 1/16″	10′ 1/16″
6′ 9″	3′ 10 3/4″	7′ 9 1/2″	8′ 9″	5′ 5/8″	10′ 1 1/4″
6′ 10″	3′ 11 5/16″	7′ 10 11/16″	8′ 10″	5′ 1 3/16	10′ 2 3/8″
6′ 11″	3′ 11 15/16″	7′ 11 13/16″	8′ 11″	5′ 1 3/4″	10′ 3 9/16″
7′ 0″	4′ 1/2″	8′ 1″	9′ 0″	5′ 2 3/8″	10′ 4 11/16″
7′ 1″	4′ 1 1/16″	8′ 2 1/8″	9′ 1″	5′ 2 15/16″	10′ 5 13/16″
7′ 2″	4′ 1 5/8″	8′ 3 5/16″	9′ 2″	5′ 3 1/2″	10′ 7″
7′ 3″	4′ 2 1/4″	8′ 4 7/16″	9′ 3″	5′ 4 1/16″	10′ 8 3/16″
7′ 4″	4′ 2 13/16″	8′ 5 5/8″	9′ 4″	5′ 4 5/8″	10′ 9 5/16″
7′ 5″	4′ 3 3/8″	8′ 6 3/4″	9′ 5″	5′ 5 1/4″	10′ 10 1/2″
7′ 6″	4′ 3 15/16″	8′ 7 15/16″	9′ 6″	5′ 5 13/16″	10′ 11 5/8″
7′ 7″	4′ 4 1/2″	8′ 9 1/16″	9′ 7″	5′ 6 3/8″	11′ 3/4″
7′ 8″	4′ 5 1/8″	8′ 10 1/4″	9′ 8″	5′ 7″	11′ 1 15/16″
7′ 9″	4′ 5 11/16″	8′ 11 3/8″	9′ 9″	5′ 7 9/16″	11′ 3 1/16″
7′ 10″	4′ 6 1/4″	9′ 1/2″	9′ 10″	5′ 8 1/8″	11′ 4 1/4″
7′ 11″	4′ 6 7/8″	9′ 1 11/16″	9′ 11″	5′ 8 11/16″	11′ 5 3/8″
8′ 0″	4′ 7 7/16″	9′ 2 7/8″	10′ 0″	5′ 9 1/4″	11′ 6 9/16″

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals of 72° Triangles Measuring from 1 Inch to 10 Feet on the Sides.

Long Leg Ft. In.	Short Leg Ft. In.	Diagonal. Ft. In.	Long Leg Ft. In.	Short Leg Ft. In.	Diagonal. Ft. In.
1"	⅜"	1 1/16"	3' 1"	1' 0"	3' 2⅞"
2"	⅝"	2⅛"	3' 2"	1' ⅜"	3' 4"
3"	1"	3⅛"	3' 3"	1' ⅝"	3' 5"
4"	1¼"	4¼"	3' 4"	1' 1"	3' 6"
5"	1⅝"	5¼"	3' 5"	1' 1¼"	3' 7⅛"
6"	2"	6¼"	3' 6"	1' 1⅝"	3' 8⅛"
7"	2¼"	7⅜"	3' 7"	1' 2"	3' 9¼"
8"	2⅝"	8⅜"	3' 8"	1' 2¼"	3' 10¼"
9"	2⅞"	9½"	3' 9"	1' 2⅝"	3' 11⅜"
10"	3¼"	10½"	3' 10"	1' 3"	4' ⅜"
11"	3⅝"	11½"	3' 11"	1' 3¼"	4' 1⅜"
12"	3⅞"	12⅝"	4' 0"	1' 3⅝"	4' 2½"
1' 1"	4¼"	1' 1⅝"	4' 1"	1' 3⅞"	4' 3½"
1' 2"	4½"	1' 2¾"	4' 2"	1' 4¼"	4' 4⅝"
1' 3"	4⅞"	1' 3¾"	4' 3"	1' 4⅝"	4' 5⅝"
1' 4"	5¼"	1' 4⅞"	4' 4"	1' 4⅞"	4' 6⅝"
1' 5"	5½"	1' 5⅞"	4' 5"	1' 5¼"	4' 7¾"
1' 6"	5⅞"	1' 6⅞"	4' 6"	1' 5½"	4' 8¾"
1' 7"	6⅛"	1' 8"	4' 7"	1' 5⅞"	4' 9⅞"
1' 8"	6½"	1' 9"	4' 8"	1' 6¼"	4' 10⅞"
1' 9"	6⅞"	1' 10⅛"	4' 9"	1' 6½"	4' 11⅞"
1' 10"	7⅛"	1' 11⅛"	4' 10"	1' 6⅞"	5' 1"
1' 11"	7½"	2' ⅛"	4' 11"	1' 7⅛"	5' 2"
2' 0"	7¾"	2' 1¼"	5' 0"	1' 7½"	5' 3⅛"
2' 1"	8⅛"	2' 2¼"	5' 1"	1' 7⅞"	5' 4⅛"
2' 2"	8½"	2' 3⅜"	5' 2"	1' 8⅛"	5' 5¼"
2' 3"	8¾"	2' 4⅜"	5' 3"	1' 8½"	5' 6¼"
2' 4"	9⅛"	2' 5⅜"	5' 4"	1' 8¾"	5' 7¼"
2' 5"	9⅜"	2' 6½"	5' 5"	1' 9⅛"	5' 8⅜"
2' 6"	9¾"	2' 7½"	5' 6"	1' 9½"	5' 9⅜"
2' 7"	10⅛"	2' 8⅝"	5' 7"	1' 9¾"	5' 10½"
2' 8"	10⅜"	2' 9⅝"	5' 8"	1' 10⅛"	5' 11½"
2' 9"	10¾"	2' 10¾"	5' 9"	1' 10⅜"	6' ½"
2' 10"	11"	2' 11¾"	5' 10"	1' 10¾"	6' 1½"
2' 11"	11⅜"	3' ¾"	5' 11"	1' 11⅛"	6' 2⅝"
3' 0"	11¾"	3' 1⅞"	6' 0"	1' 11⅜"	6' 3⅝"

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Table of Diagonals of 72° Triangles Measuring from 1 Inch to 10 Feet on the Sides.

Long Leg Ft. In.	Short Leg Ft. In.	Diagonal. Ft. In.	Long Leg Ft. In.	Short Leg Ft. In.	Diagonal, Ft. In.
6′ 1″	1′ 11¾″	6′ 4¾″	8′ 1″	2′ 7½″	8′ 6″
6′ 2″	2′ 0″	6′ 5¾″	8′ 2″	2′ 7⅞″	8′ 7″
6′ 3″	2′ ⅜″	6′ 6⅞″	8′ 3″	2′ 8⅛″	8′ 8⅛″
6′ 4″	2′ ¾″	6′ 7⅞″	8′ 4″	2′ 8½″	8′ 9⅛″
6′ 5″	2′ 1″	6′ 8⅞″	8′ 5″	2′ 8⅞″	8′ 10¼″
6′ 6″	2′ 1⅜″	6′ 10″	8′ 6″	2′ 9⅛″	8′ 11¼″
6′ 7″	2′ 1⅝″	6′ 11⅛″	8′ 7″	2′ 9½″	9′ ¼″
6′ 8″	2′ 2″	7′ ⅛″	8′ 8″	2′ 9¾″	9′ 1⅜″
6′ 9″	2′ 2⅜″	7′ 1⅛″	8′ 9″	2′ 10⅛″	9′ 2⅜″
6′ 10″	2′ 2⅝″	7′ 2½″	8′ 10″	2′ 10½″	9′ 3½″
6′ 11″	2′ 3″	7′ 3¼″	8′ 11″	2′ 10¾″	9′ 4¼″
7′ 0″	2′ 3¼″	7′ 4⅜″	9′ 0″	2′ 11⅛″	9′ 5½″
7′ 1″	2′ 3⅝″	7′ 5⅜″	9′ 1″	2′ 11⅜″	9′ 6⅝″
7′ 2″	2′ 4″	7′ 6⅜″	9′ 2″	2′ 11¾″	9′ 7⅝″
7′ 3″	2′ 4½″	7′ 7½″	9′ 3″	3′ ⅛″	9′ 8¾″
7′ 4″	2′ 4⅝″	7′ 8½″	9′ 4″	3′ ⅜″	9′ 9¾″
7′ 5″	2′ 4⅞″	7′ 9½″	9′ 5″	3′ ¾″	9′ 10⅞″
7′ 6″	2′ 5¼″	7′ 10⅝″	9′ 6″	3′ 1″	9′ 11⅞″
7′ 7″	2′ 5⅝″	7′ 11⅝″	9′ 7″	3′ 1⅜″	10′ ⅞″
7′ 8″	2′ 5⅞″	8′ ¾″	9′ 8″	3′ 1¾″	10′ 2″
7′ 9″	2′ 6¼″	8′ 1¾″	9′ 9″	3′ 2″	10′ 3″
7′ 10″	2′ 6½″	8′ 2¾″	9′ 10″	3′ 2⅜″	10′ 4⅛″
7′ 11″	2′ 6⅞″	8′ 3⅞″	9′ 11″	3′ 2⅝″	10′ 5⅛″
8′ 0″	2′ 7¼″	8′ 5″	10′ 0″	3′ 3″	10′ 6⅛″

Extreme caution must be exercised in taking off centers of fittings in these measurements.

Illustration showing how to obtain measurements of all kinds of bends used in heavy duty work

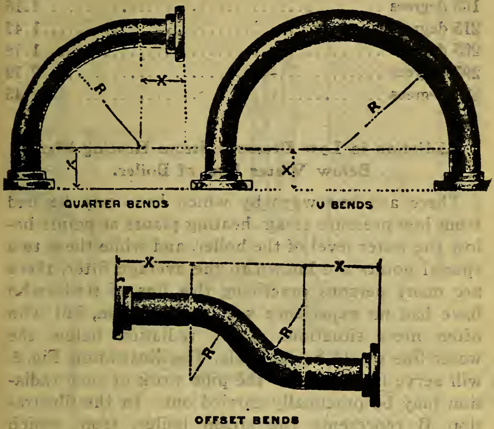


Fig. 7

The radius of any bend should not be less than 5 diameters of the pipe and a larger radius is much preferable. The length "X" of straight pipe at each end of bend should be not less than as follows:

2½-in. Pipe	X=4 in.	8-in. Pipe	X= 9 in.
3 -in. Pipe	X=4 in.	10-in. Pipe	X=12 in.
3½-in. Pipe	X=5 in.	12-in. Pipe	X=14 in.
4 -in. Pipe	X=5 in.	14-in. Pipe	X=16 in.
4½-in. Pipe	X=6 in.	15-in. Pipe	X=16 in.
5 -in. Pipe	X=6 in.	16-in. Pipe	X=20 in.
6 -in. Pipe	X=7 in.	18-in. Pipe	X=22 in.
7 -in. Pipe	X=8 in.		

Table Showing Expansion of Iron Pipe for Each 100 Feet, in Inches, from 30 Degrees.

Temperature	Expansion in inches.
165 degrees	1.15
215 degrees	1.47
265 degrees	1.78
297 degrees	2.12
338 degrees	2.45

Radiation in Low Pressure Steam Heating Plant Below Water Line of Boiler.

There are two ways by which heat may be had from low pressure steam heating plants at points below the water level of the boiler, and while these two special points are known to the average fitter, there are many persons practicing this line of trade who have had no experience with such system, but who often meet situations where radiation below the water line would be desirable. The illustration, Fig. 8, will serve to show how the pipe work of such radiation may be practically carried out. In the illustration B represents the steam boiler, from which steam may be carried to the various radiators situated above the boiler and having the usual return pipe to bring back the condensation to the boiler.

The highest point to which water rises, or the water level, is indicated by W, and on the right side of boiler is a return bend coil, all of which is situated below the water level, and which can be used as radiating surface. Through this coil the water from the steam boiler can be made to circulate, and will be found to be very effective. Both connections of the coil should be provided in such cases with valves as shown, and while one valve would answer the purpose of stopping the circulation, it is always best to provide against a leak in the coil, so that a valve in each branch to the boiler might save

Radiation in Low Pressure Steam Heating Plant Below Water Line of Boiler.

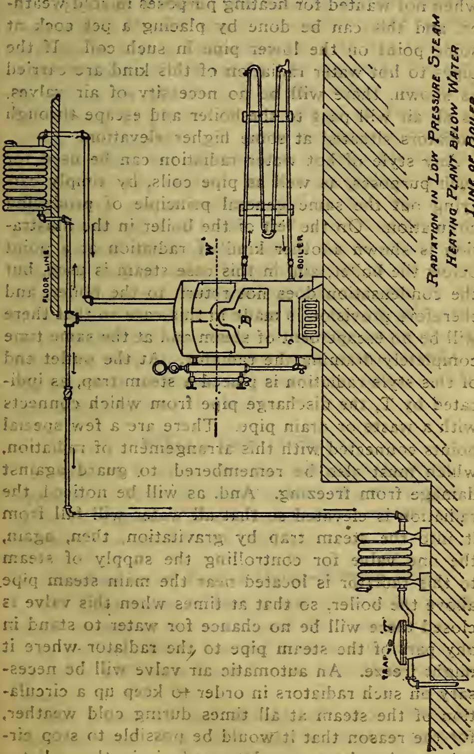


Fig. 8.

trouble and annoyance. Then where such radiation as shown on the right of boiler is used, provision should always be made to drain the coils of water when not wanted for heating purposes in cold weather, and this can be done by placing a pet cock at some point on the lower pipe in such coil. If the pipes to hot water radiation of this kind are carried as shown, there will be no necessity of air valves, as all air will pass to the boiler and escape through radiators situated at some higher elevation.

Any style of hot water radiation can be used for such purposes, as well as pipe coils, by simply carrying out the same general principle of producing circulation. On the left of the boiler in the illustration is shown another kind of radiation at a point below the boiler, and in this case steam is used, but the condensation does not return to the boiler, and therefore provision is made in this case so that there will be no escapement of steam and at the same time completely draining the radiator. At the outlet end of this style radiation is placed a steam trap, as indicated by T, the discharge pipe from which connects with a waste or drain pipe. There are a few special points connected with this arrangement of radiation, which must also be remembered, to guard against damage from freezing. And, as will be noticed, the radiation is elevated so that all water will fall from it into the steam trap by gravitation, then, again, the one valve for controlling the supply of steam to this radiator is located near the main steam pipe above the boiler, so that at times when this valve is closed there will be no chance for water to stand in any part of the steam pipe to the radiator where it might freeze. An automatic air valve will be necessary on such radiators in order to keep up a circulation of the steam at all times during cold weather, for the reason that it would be possible to stop circulation by the accumulation of air in the radiator

with an ordinary direct air valve, and with the steam supply valve on main pipe wide open, and under such circumstances it would be possible for the water to freeze in the steam trap, thus closing the outlet and allowing the radiator and all connections to it to fill with water. Therefore it will be seen that this is a very important place to use the best make of automatic air valves. In regard to the supply valves on all lines, if globe valves are used, they should be placed at an angle of 45 degrees, as shown in illustration, in order to prevent trapping of these lines, but gate valves in such places may be placed at any angles. In heating systems of this kind where steam radiation is located below the water level of the boiler and condensation from such surface discharged through steam traps, there will be a loss of water from the boiler to the extent of such condensation, and on this account, it will be necessary to place on the boiler a reliable automatic water feeder connected to the water service supply to keep the water up to its proper height in the boiler at all times, and not alone to save attention but to protect the boiler.

What a Unit of Heat is.

A unit of heat is that amount of heat which is required to raise the temperature of one pound of water 1 degree F., and is used to calculate and measure the quantity of heat.

Combustion of Fuel in House-Heating Boilers.

The combustion of fuel in any given area of grate must depend on the rapidity of the draught.

In ordinary home heating boilers, one square foot of grate will burn from 5 to 8 pounds of coal per hour.

One pound of coal should add about 9000 heat units to water in a boiler used for heating purposes.

One cubic foot of ordinary coal gas contains 650 units of heat, but 50% of this is lost in the generating of steam or heating of water by even the best construction of Bunsen or atmospheric burners, so that 1 cubic foot of 16 candle power gas will add about 325 units of heat to water below 200 degrees F.

A most important thing in the construction of steam heating plants, is to properly proportion the boiler, the grate surface with the heating surface, also the proper area of chimney for a proper and economical consumption of the fuel, and for this purpose the diagrams on page 38 have been arranged, and which are the result of practical experience and tests under various conditions.

It will be noticed in referring to plate, Fig. 9, that one square foot of grate surface will supply 36 square feet of boiler surface; and this amount of grate and boiler surface will carry 196 square feet of direct radiating surface for heating purposes. The area of chimney must be taken into consideration, and for this amount we allow 49 square inches.

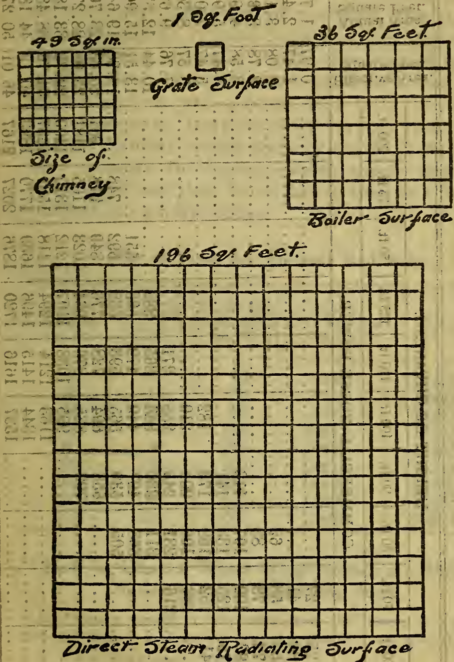

1 Sq. Foot
49 Sq. in.
36 Sq. Feet
Grate Surface
Size of Chimney
Boiler Surface
196 Sq. Feet
Direct Steam Radiating Surface

Fig. 9

Table Showing Sizes of Chimneys with Approximate Horse Power Boilers.

Diameter in inches.	HEIGHT OF CHIMNEYS.											Effective Area, Square Feet.	Actual Area, Square Feet.	Size of Square of Approximate Area, Inches.
	50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.	110 ft.	125 ft.	150 ft.	175 ft.	200 ft.			
	COMMERCIAL HORSE POWER.													
18	23	25	27	......	......	......	......	......	......	......	......	0.97	1.77	16
21	35	38	41	......	......	......	......	......	......	......	......	1.47	2.41	19
24	49	54	58	62	......	......	......	......	......	......	......	2.08	3.14	22
27	65	72	78	83	......	......	......	......	......	......	......	2.78	3.98	24
30	84	92	100	107	113	......	......	......	......	......	......	3.58	4.91	27
33	......	115	125	133	141	......	......	......	......	......	......	4.47	5.94	30
36	......	141	152	163	173	182	......	......	......	......	......	5.47	7.07	32
39	......	......	183	196	208	219	......	......	......	......	......	6.57	8.30	35
42	......	......	216	231	245	258	271	......	......	......	......	7.76	9.62	38
48	......	......	......	311	330	348	365	389	......	......	......	10.44	12.57	43
54	......	......	......	363	427	449	472	503	551	......	......	13.51	15.90	48
60	......	......	......	505	539	565	593	632	692	748	......	16.98	19.64	54
66	......	......	......	......	658	694	728	776	849	918	981	20.83	23.76	59
72	......	......	......	......	792	835	876	934	1023	1105	1181	25.08	28.27	64
78	......	......	......	......	......	995	1038	1107	1212	1310	1400	29.73	33.18	70
84	......	......	......	......	......	1163	1214	1294	1418	1531	1637	34.76	38.48	75
90	......	......	......	......	......	1344	1415	1496	1639	1770	1893	40.19	44.18	80
96	......	......	......	......	......	1537	1616	1720	1876	2027	2167	46.01	50.27	86

Chimney Flues.

For low pressure gravity steam heating plants, carrying over 1000 feet of radiation, the size of chimney may be reduced somewhat less in proportion than that shown in Fig. 9. The success of any heating plant depends largely on the chimney, and no matter how well a boiler may be proportioned and constructed, there cannot be proper results unless the chimney is also properly constructed. Chimneys intended for heating plants should never be constructed less than 8x8 inches in the clear for the smallest size private house.

Size of Flues for Indirect Radiation.

Heating Surface, Sq. Ft.	Area of Cold Air Supply, Sq. In.	Area of Hot Air Supply, Sq. In.	Size of Brick Flue for Hot Air.	Size of Register.
20	30	40	4x12	8x 8
30	45	60	8x12	8x12
40	60	80	8x12	10x12
50	75	100	12x12	10x15
60	90	120	12x12	12x15
80	120	160	12x16	14x18
100	150	200	12x20	16x20
120	180	240	14x20	16x24
140	210	280	16x20	20x24

How to Clean a Water Gauge Glass on a Steam Boiler Without Removing Same.

1. Draw a cupful of hot water from the boiler, into which pour at least a tablespoonful of raw muriatic or other acid.

2. Close both water gauge valves.

3. Open top water gauge valve and also pet cock at bottom and blow water out of the glass. Then immediately close the top valve and submerge the end of the pet cock in cup of hot water solution. A vacuum is at once created in the gauge glass which causes the solution in the cup to rush in.

4. Keep the pet cock immersed and operate the top valve, slightly opening and closing, alternately expelling and draw-

ing in the solution until all grease, oil, or other matter adhering to the inside of the glass is cut out. Then close pet cock and open both water gauge valves.

It is necessary to have one pound pressure of steam or more on the boiler before commencing this operation, which need not occupy more than ten minutes. The result is a clean glass without the risk of breakage and probable renewal of gaskets, which is frequently the case when removing the glass for cleaning.

Removing Oil and Grit from Steam Boiler.

Unavoidable accumulation of oil, grease or grit in a new system causes a boiler to foam, prevents generation of steam, and produces an unsteady water line; therefore it is necessary to blow off boiler under pressure.

1. Close off the main steam and return valves, or all radiator valves.

2. Make a wood fire and get up a pressure of at least ten pounds as indicated by the steam gauge.

3. Open the blow-off valves, being careful that just sufficient fire is carried to maintain a pressure until the last gallon of water is exhausted.

4. Allow fire to die out.
5. Open all fire and flue doors and in about half an hour.
6. Close blow-off valve and
7. Refill boiler slowly to water line.
8. Open all radiator and main valves and
9. Start fire.

A boiler should be blown off within a week after it is installed and in operation. If one blowing off does not result in clean water gauge glass, proper generation of steam and a steady water line, the boiler should be blown off a second, and if necessary a third and fourth time.

Table of Relative Sizes of One Pipe Steam Main Showing Feet of Radiation Pipe it will take care of.

1 inch	40	to	50	feet of radiation.
1¼ inch	100	to	125	feet of radiation.
1½ inch	125	to	250	feet of radiation.
2 inch	250	to	400	feet of radiation.
2½ inch	400	to	650	feet of radiation.
3 inch	650	to	900	feet of radiation.
3½ inch	900	to	1250	feet of radiation.
4 inch	1250	to	1600	feet of radiation.
4½ inch	1600	to	2050	feet of radiation.
5 inch	2050	to	2500	feet of radiation.
6 inch	2500	to	3600	feet of radiation.
7 inch	3600	to	5000	feet of radiation.
8 inch	5000	to	6500	feet of radiation.
9 inch	6500	to	8100	feet of radiation.
10 inch	8100	to	10000	feet of radiation.

Table Showing Various Sizes of Pipe Constituting a Foot of Radiation.

Water and steam the same.

36 inches 1 -inch pipe makes 1 foot of radiation.
28 inches 1¼-inch pipe makes 1 foot of radiation.
24 inches 1½-inch pipe makes 1 foot of radiation.
20 inches 2 -inch pipe makes 1 foot of radiation.
16 inches 2½-inch pipe makes 1 foot of radiation.
13 inches 3 -inch pipe makes 1 foot of radiation.
9½ inches 3½-inch pipe makes 1 foot of radiation.
8½ inches 4 -inch pipe makes 1 foot of radiation.
6½ inches 5 -inch pipe makes 1 foot of radiation.
5½ inches 6 -inch pipe makes 1 foot of radiation.

Tables of Mains and Branches for Hot Water.

1¼ in. will supply 2 ....1 in.
1½ in. will supply 2 ....1¼ in.
2 in. will supply 2 ....1½ in.
2½ in. will supply 2 1½-in. and 1 1¼-in., or 1 2 -in. and 1 1¼-in.
3 -in. will supply 1 2½-in. and 1 2 -in., or 2 2 -in. and 1 1½-in.
3½ in. will supply 2 2½-in. or 1 3 -in., and 1 2 -in. or 3 2 -in.
4 -in. will supply 1 3½-in. and 1 2½-in., or 2 3 -in. and 4 2 -in.
4½ in. will supply 1 3½-in. and 1 3 -in., or 1 4 -in. and 1 2½-in.
5 -in. will supply 1 4 -in. and 1 3 -in., or 1 4½-in. and 1 2½-in.
6 -in. will supply 2 4 -in. and 1 3 -in., or 4 3 -in. or 10 2 -in.
7 -in. will supply 1 6 -in. and 1 4 -in., or 3 4 -in. and 1 2 -in.
8 -in. will supply 2 6 -in. and 1 5 -in., or 5 4 -in. and 2 2 -in.

Size of Mains for Two Pipe Steam Systems.

In calculating on the proper size of steam mains for gravity systems, lengths of such pipes as well as the square feet of surface in same must be considered. In situations where long runs of pipe are necessary between the boiler and radiating surface proper, one size larger pipe should be used for each 100 feet, and at the same time all mains figured as radiating surface when deciding on the sizes of such main pipe.

Radiating Surface Pipe will Supply.

Size of Pipe, Feed: Return.	Area, Inches.	RADIATION.	
		Direct.	Indirect.
1¼x1	1.49	150	85
1½x1¼	2.03	225	140
2 x1¼	3.35	350	200
2½x1½	4.78	500	300
3 x2	7.38	800	500
3½x2	9.83	1100	700
4 x2½	12.73	1500	1000
4½x2½	15.93	1800	1200
5 x3	19.99	2400	1600
6 x3½	28.88	3600	2200
7 x4	38.73	5000	3000
8 x4½	50.03	6500	4000
9 x5	63.63	8000	5400
10 x6	78.83	10000	7000

Branches to radiators should always be taken off the top of the main, using a square Ell or a 45° Ell.

A practical man will always do this.

Measurement of Supply and Return Pipes.

To ascertain the amount of heating surface in supply, return pipes and risers, multiply length of pipe by figures given below, always pointing off two places.

Example: 200 lineal feet 1½-inch pipe multiplied by 50 equals 100 square feet heating surface.

Size of Pipe.	Square Feet in One Lineal Foot.	Gallons of Water in 100 Feet in Length.
¾-inch.	.27	2.77 gallons.
1 -inch.	.34	4.50 gallons.
1¼-inch.	.43	7.75 gallons.
1½-inch.	.50	10.59 gallons.
2 -inch.	.62	17.43 gallons.
2½-inch.	.75	24.80 gallons.
3 -inch.	.92	38.38 gallons.
3½-inch.	1.05	51.36 gallons.
4 -inch.	1.17	66.13 gallons.

Square Feet of Direct Steam Radiation.	Horse Power.	Size of Chimney.	Square Feet of Direct Water Radiation.
250	2.5	8x 8	400
300	3.0	8x 8	500
400	4.0	8x 8	700
500	5.0	8x12	850
600	6.0	8x12	1000
700	7.0	8x12	1200
800	8.0	12x12	1350
900	9.0	12x12	1500
1000	10.0	12x12	1700
1200	12.0	12x12	2100
1400	14.0	12x16	2400
1600	16.0	12x16	2700
1800	18.0	12x16	3000
2000	20.0	12x16	3400
2200	22 0	16x16	3700
3000	30.0	16x16	5100
3500	35.0	16x20	5900
5000	50.0	16x20	8500
5500	55.0	20x20	9300
8000	80.0	20x20	13000

Size of Mains for One Pipe Hot Water System.

Do not reduce size of mains too rapidly as branches are taken off. The increased friction of smaller pipe is frequently too great to admit of any reduction in the size of main.

For direct radiation the area of the mains may be arrived at by multiplying radiating surface.

When 1800 feet and less by .011

When 2000 feet and over by .009

Use pipe having area nearest to that so found.

Under ordinary conditions, the following table for size of mains will be found entirely reliable:—

Size of Main, Inches.	Area.	Direct Radiation Will Supply, Feet.	Indirect Radiation Will Supply. Feet.
1½	2.03	200	135
2	3.35	325	200
2½	4.78	450	300
3	7.38	700	450
3½	9.82	900	600
4	12.73	1200	800
4½	15.93	1500	1000
5	19.99	2000	1200
6	28.88	3000	2000
7	38.73	4200	2800
8	50.03	5600	3600
9	63.63	7000	4600
10	78.83	8500	5600

Size of Mains for Two Pipe Hot Water System.

Size of Main. Feed. Return.	Area.	Direct Radiation will Supply, Feet.	Feet.
1½ x 1½	4.06	From 275	To 350
2 x 2	6.70	400	650
2½ x 2½	9.56	800	1000
3 x 3	14.76	1300	1500
3½ x 3½	19.64	1700	1950
4 x 4	25.46	2450	2950
4½ x 4½	31.86	3275	3500
5 x 5	39.98	3700	4450
6 x 6	57.76	5400	6050
7 x 7	77.46	7275	9400
8 x 8	100.06	11000	12400
9 x 9	127.26	14000	15500
10 x 10	157.66	17000	19000

Refer to page 42, third table, for Branches.

Horizontal Tubular Boilers.

Diam of Shell.	Length of Shell.	No. of Tubes.	Diam. of Tubes.	Length of Tubes.	Gauge of Shell.	Gauge of Heads	Heat'g Surface	Horse Power
60	19	65	3½	18	⅜	½	1147	76
60	18	65	3½	17	⅜	½	1074	72
60	17	65	3½	16	⅜	½	1006	67
60	17	92	3	16	⅜	7/16	1229	82
60	16	92	3	15	⅜	7/16	1152	77
60	15	92	3	14	⅜	7/16	1075	72
60	14	92	3	13	⅜	7/16	998	67
54	19	50	3½	18	5/16	½	951	63
54	18	50	3½	17	5/16	½	900	60
54	17	50	3½	16	5/16	½	795	53
54	17	72	3	16	5/16	7/16	977	65
54	16	72	3	15	5/16	7/16	917	61
54	15	72	3	14	5/16	7/16	857	57
54	14	72	3	13	5/16	7/16	797	53
54	13	72	3	12	5/16	7/16	735	49
48	17	40	3½	16	5/16	⅜	683	46
48	17	49	3	16	5/16	⅜	684	46
48	16	49	3	15	5/16	⅜	642	43
48	15	49	3	14	5/16	⅜	600	40
48	14	49	3	13	5/16	⅜	555	37
48	13	49	3	12	5/16	⅜	513	34
48	12	65	2½	11	5/16	⅜	542	36
42	16	38	3	15	¼	⅜	508	34
42	15	38	3	14	¼	⅜	476	32
42	14	38	3	13	¼	⅜	441	30
42	13	38	3	12	¼	⅜	408	27
42	12	45	2½	11	¼	⅜	390	26
42	11	45	2½	10	¼	⅜	355	24
42	10	45	2½	9	¼	⅜	320	22
42	9	45	2½	8	¼	⅜	285	19
42	8	45	2½	7	¼	⅜	248	16
36	13	28	3	12	¼	⅜	306	20
36	12	34	2½	11	¼	⅜	298	20
36	11	34	2½	10	¼	⅜	271	18
36	10	34	2½	9	¼	⅜	244	16
36	9	34	2½	8	¼	⅜	211	14
36	8	34	2½	7	¼	⅜	190	12
30	9	30	2	8	¼	⅜	152	10
30	8	30	2	7	¼	⅜	133	8
30	7	30	2	6	¼	⅜	114	7
30	6	30	2	5	¼	⅜	95	6

Water Capacity of a Boiler.

To find the water capacity of any horizontal tubular boiler, 1-3 being allowed for water space.

1. Multiply area of head by length of boiler in inches.

2. Multiply area of one tube by length and the result by number of tubes.

3. Deduct amount given from first amount and divide by 231 (cubic inches in gal.) quotient will be answer in gallons. Take $\frac{2}{3}$ for amount wanted.

Example.

Boiler, 6 feet by 18 inches. 100 3-inch tubes

Length of tubes	216
Area of tubes	7
	1512
Number of tubes	100
	151200 cu.in.
Area of boiler.........................	4071.51
Length of boiler.......................	216
	24429.06
	40715.1
	814302
Total cubic inches boiler	879446.16
Deduct cubic inches in tubes	151200
Divide by 231 (cubic inches in gallon)	231)728246.16(3152.58
	693
	352
	231
	1214
	1155
	596
	462
	1341
	1155
Answer $\frac{2}{3}$ of 3152.58=2101.71.	1866

Horizontal Fire Box Boilers for Steam and Hot Water Heating

Diam. of Shell........inches	30	30	30	36	36	36	42	42	42	48	48	48	54	54
Length over all..........feet	6½	7½	8½	7½	9	10½	8½	10	11½	10½	12	13½	14	16½
Number of Tubes...........	40	40	40	40	40	40	52	52	52	48	48	48	34	34
Diam. of Tubes........inches	2	2	2	2½	2½	2½	2½	2½	2½	3	3	3	4	4
Fire Doors.														
Single Doors........inches	12x18	12x18	12x18	......	......	......	......	......	......	......	......	......	......	......
Double Doors.......inches	......	......	......	16x22	16x22	16x22	16x24	16x24	16x24	18x30	18x30	18x30	18x30	18x30
Steam Tappings.														
Steam Outlet. ......inches	3	3	4	4	4	4	4	6	6	6	6	6	7	7
Return Inlet.........inches	2½	2½	3	3	3	3	3	4	4	4	4	4	5	5
Water Tappings.														
Flow and Return....inches	3	3	3½	3½	4	4	4	5	5	5	6	6	7	7
Tapping for Safety Valve ....inches	1	1	1	1¼	1¼	1¼	1½	1½	1½	2	2	2	2½	2½
Size of Smoke Pipe....inches	14	14	14	16	16	16	18	18	18	22	22	22	24	24
Total Heating Surface..sq. ft.	152	172	194	211	252	292	295	347	399	421	482	541	580	720
Grate Area.............sq. ft.	4.3	5.3	6.3	6.7	8	9.2	9.5	11	12.5	13	14.7	16.4	18.6	20.6
Radiation will carry, Direct Steam..............	850	950	1100	1200	1500	1800	1800	2200	2600	2800	3300	3800	4500	5800
Radiation will carry, Direct Water..............	1350	1500	1750	1900	2400	2900	2900	3500	4200	4500	5300	6100	7200	9300

Heating Surface of Boilers.

In considering the question, "What is good and proper heating surface in steam boilers?" we take the horizontal tubular style of boilers as the standard, and any construction of cast or wrought iron boiler with as good heating surface may be figured in the same manner as to capacity.

Boiler Capacity.

If you wish to install a boiler that will be economical and require only moderate attention, do not select a boiler with a rating agreeing with the surface to be heated. Allow from 15 to 25 per cent. reserve power for emergencies—remembering that other factors beside the radiation affect the boiler, such as the care or management it receives, the fuel used and the chimney draft.

Rating of Tubular Boilers.

In figuring radiation, for every horse power allow 100 square feet of direct radiation.

Determining Size of Boiler when Pipe Coil is used for Heating Water for Domestic Purposes.

When a pipe coil or cast iron section is introduced into the firepot for the purpose of heating water for domestic use, additional capacity should be figured in determining size of Boiler, viz., in the case of Steam Boilers, 1¼ square feet of direct radiation for each gallon of water to be thus heated, and in the case of Water Boilers, 2 square feet of direct radiation for each gallon of water to be thus heated, according to the capacity of the tank to which coil or section is connected.

When indirect radiation is to be used, not less than

75 per cent increase over direct radiation should be figured in determining the size of boiler required.

In rating steam boilers as above, it is understood that an average pressure of two pounds will be maintained at the Boiler. In rating water boilers as above, it is understood that the mean temperature of the water at the Boiler will be 180 degrees Fahrenheit.

Size of Fresh Air Inlets to Indirect Stacks.

Where natural draught is depended upon for the movement of cold air to the indirect stacks of steam radiation, practice has found that for each square foot of radiation 1½ square inches of opening for cold air supply is necessary, or, in other words, for each 10 square feet of indirect radiation 15 square inches of cold air opening will answer.

The Amount of Direct Radiation that can be Heated by Exhaust Steam.

In calculating the heating capacity of an engine from its exhaust steam, there will be some difference in the make or style of such engine from which the exhaust steam is taken, and the better the engine the less will be the heating capacity per horse power of such engine from its exhaust steam; at the same time it will be a safe plan, based on practical experience, to allow from 100 to 125 feet of direct radiation per horse power of engine from which the exhaust steam is taken. Condensing engines, of course, not being considered for such purposes.

In exhaust steam heating plants where the feed water is heated by the exhaust steam, much of the heat from the exhaust steam will be extracted from the exhaust system by the feed water; and therefore this must be taken into consideration.

Locating Radiators.

Direct Radiation.

Direct radiation should be set along the exposed or cold walls or under the windows, in order to warm the cold currents of air produced by these exposures.

If placed on the warm side of a room the tendency is to cause a draft of cold air across the floor, endangering health, or, if nothing worse, causes cold feet. Usually, in residences, sufficient radiation is placed on the first (or lower) hall to heat the cubic contents of the halls on all floors, but in a three-story building, where the halls are large, we advise the placing of some radiation in the second floor, unless there is an unprotected glass exposure (skylight) over the hall, in which case the radiation should be put in the third story instead of second, to heat the cold air as it descends.

Weight and Measurement of a Square Foot of Radiation.

A foot of prime radiation should weigh 6¾ pounds and hold one pint of water.

Radiation of Different Sizes of Wrought Iron Pipe.

Following table gives the actual lengths of different size pipe sufficient to make ten square feet of radiation.

1 -inch pipe, 28 lineal feet=10 square feet radiation.
1¼-inch pipe, 24 lineal feet=10 square feet radiation.
1½-inch pipe, 20 lineal feet=10 square feet radiation.
2 -inch pipe, 16 lineal feet=10 square feet radiation.
2½-inch pipe, 13 lineal feet=10 square feet radiation.
3 -inch pipe, 11 lineal feet=10 square feet radiation.

Trouble from Improper Turning of Steam Radiator Valves.

Still another source of trouble and loss of water from the boiler comes in the manner in which radiator valves are handled, especially on the two pipe system, and this is when it is desirable to close off the heat: The inlet valve is closed, while the return valve may be left partly or entirely open, thus allowing condensation to back up from some other source and thus storing up a considerable amount of water in the radiator, to the detriment of the boiler, because this water is not intended to accumulate in any part of the system above the return pipes, but fall by gravitation to the boiler. It will therefore be seen that on two pipe radiators, both valves must be left wide open or both perfectly closed, in order to have the apparatus operate in a proper manner. The same applies to a one pipe system as well.

Tapping for Radiators.

One Pipe Work.

Less than 24 feet, 1 inch pipe.
Over 24 feet up to 50 feet, 1¼ inch pipe.
Over 50 feet up to 90 feet, 1½ inch pipe.
Over 90 feet up to 150 feet, 2 inch pipe.

Two Pipe Work.

Less than 30 feet, 1x¾.
30 to 60 feet, 1¼x1.
50 to 100 feet, 1½x1¼.
100 to 160 feet, 2 x1½.

Indirect Radiators.

30 to 50 feet, 1¼x1 inches.
50 to 100 feet, 1½x1¼ inches.
100 to 150 feet, 2 x1½ inches.

Hot Water Tapped for Supply and Return.

Radiators containing 40 square feet and under 1 -in.
Above 40, but not exceeding 72 square feet 1¼-in.
Above 72 square feet........................1½-in.

Illustration Showing Best Methods of Making One Pipe Steam Radiator Connection.

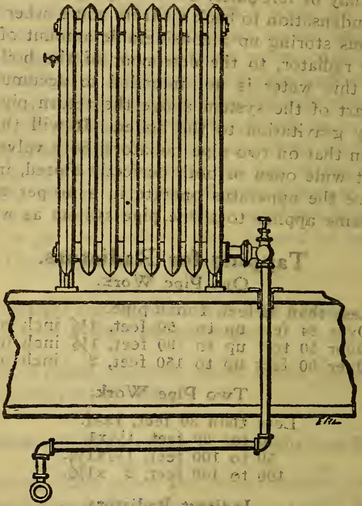


Fig. 10.

Method of Connecting Radiator to Riser on One Pipe Steam System.

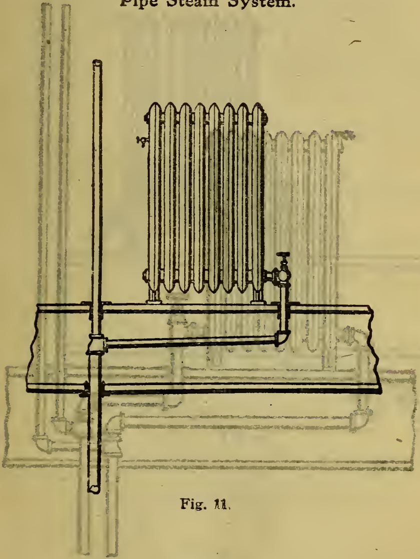


Fig. 11.

Figures 12, 13, 14 and 15 Show Best Methods of Making Hot Water Radiator Connections.

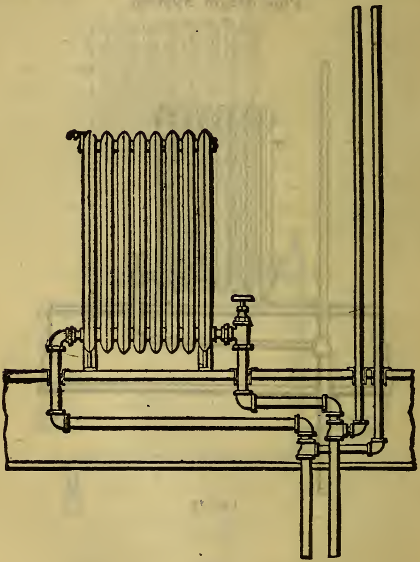


Fig. 12.

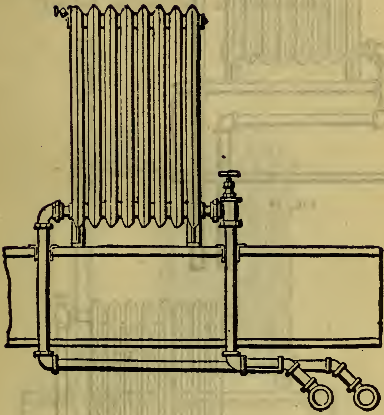


Fig. 13.

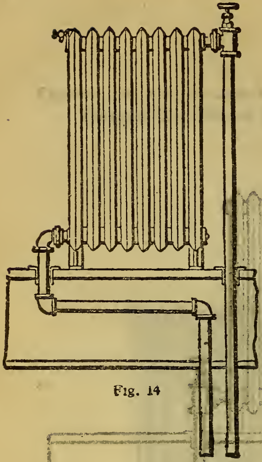


Fig. 14

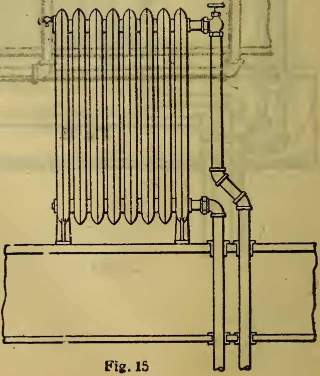


Fig. 15

Figures 16 and 17 Show Proper Methods of Connecting Hot Water Radiators From Overhead Systems. Air Valves Are Not Needed in Systems of This Kind.

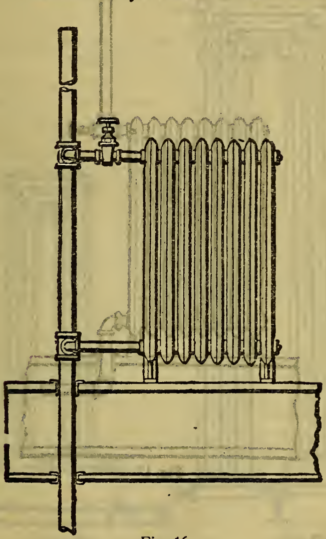


Fig. 16.

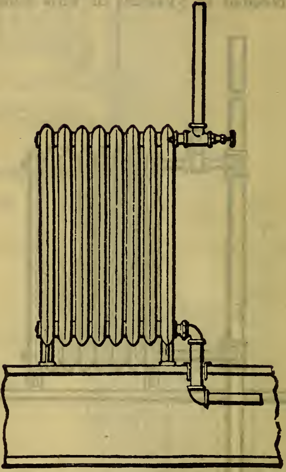


Fig. 17

Figures 18 and 19 Show Best Method of Constructing Hot Water Coils For 1 and 2 Pipe Systems.

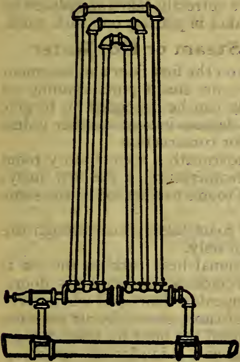


Fig. 18.

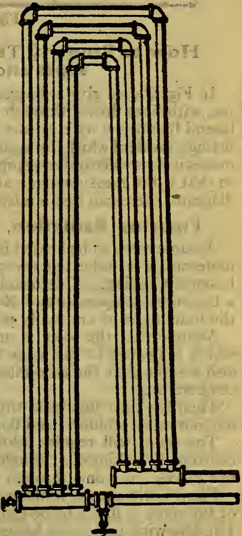


Fig. 19.

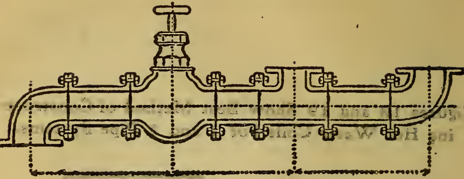


Fig. 20

How to Properly Take Measurements of Pipes and Fittings

In Fig. 20, we give a diagram of two elbows, a valve, and a tee, with lines drawn through the center of each fitting, also a lateral line below with arrows indicating the center points of fittings, inside of which the measurements are to be marked. This makes it clear when ordering pipe work with fittings cut to order, so that if the measurements are correctly taken and placed on diagram, there can be no mistakes in getting out such work.

Figuring Radiation, Steam or Hot Water

Assume room to be heated is on the first floor and basement underneath is unheated except for steam pipes running on basement ceiling. This usually can be depended on to give a basement temperature of 40 degrees in zero weather unless the building is of unusually poor construction.

Assume that the room is underneath a second story room which is heated to the same temperature as the first story; also assume that the adjoining rooms are heated to the same temperature.

Then the heat loss from the room takes place through the outside walls, windows and floor only.

The room will require additional heat because the air is continually leaking out through cracks around windows, doors, fire places, etc., and through opening doors and windows.

First: Estimate the number of times the entire air contents of the room is likely to be changed per hour by this leakage. The following table may be used as a guide for this estimate:

Halls	2 to 3	Drug stores	3
Living rooms	2 to 3	Clothing stores	1
Dining rooms	1 to 2	Jewelry stores	1
Kitchens	2	Grocery stores	1 to 2
Bedrooms	2	Law offices	1
Sewing rooms	2	Doctors' offices	1 to 2
Second floor halls	1	Dentists' offices	1 to 2

The number of cubic feet of air per hour to be heated is found by multiplying the cubic feet contents of the room

by the number of air changes. Look at the illustration (Fig. 21, page 67), and you will note a room 13'×15'×10', which equals 1950 cubic feet of space.

If we have decided on two air changes per hour, then we must heat 2×1950=3900 cubic feet of air from outdoor temperature to the room temperature. Let us take this as 70 degrees difference, which equals 70 degrees temperature in

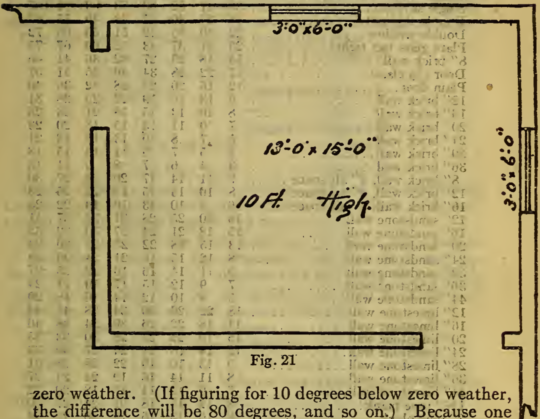


Fig. 21

zero weather. (If figuring for 10 degrees below zero weather, the difference will be 80 degrees, and so on.) Because one heat unit (B. T. U. or U) is needed to raise 50 cubic feet of air 1 degree, we will use 1.4 heat units to heat 1 cubic foot of air 70 degrees, and 3900 cubic feet will require 3900×1.4=5460 heat units (U).

The following table gives the heat units required for different weather conditions:

For 30 deg. difference in temperature, multiply each cu. ft. of air by .6.
For 40 deg. difference in temperature, multiply each cu. ft. of air by .8.
For 50 deg. difference in temperature, multiply each cu. ft. of air by 1.0.
For 60 deg. difference in temperature, multiply each cu. ft. of air by 1.2.
For 70 deg. difference in temperature, multiply each cu. ft. of air by 1.4.
For 80 deg. difference in temperature, multiply each cu. ft. of air by 1.6.
For 90 deg. difference in temperature, multiply each cu. ft. of air by 1.8.

Again looking at the illustration (Fig. 21, page 67), you will note that heat will be lost through both outside walls and windows.

13'+15'=28'×10'=280 sq. ft.

2 windows at 3'×6'=36 sq. ft. glass.

280−36=244 sq. ft. net wall.

The following table gives the heat units lost in one hour for each square foot of exposure of different materials used in buildings:

Type of Construction	30	40	50	60	70	80	90	100
Single window (good)	34	45	59	67	75	86	98	110
Single window (average)	36	48	61	73	86	98	110	123
Single skylight	30	41	52	63	73	83	94	105
Double skylight	18	24	30	37	43	49	55	62
Double window	22	30	36	42	51	59	66	72
Plate glass (set tight)	23	31	37	43	52	60	67	75
8″ brick wall	14	18	23	27	32	36	41	46
Door (½ glass)	17	22	28	34	40	45	51	57
Plain door	12	16	20	24	28	32	36	40
12″ brick wall	9	13	16	19	22	25	28	31
16″ brick wall	8	10	13	15	18	21	23	26
20″ brick wall	7	9	11	13	15	18	20	23
24″ brick wall	5	7	8	10	13	15	18	21
30″ brick wall	4	5	7	9	11	13	15	18
36″ brick wall	3	4	6	7	8	9	11	13
8″ brick wall, 3″ air space	9	11	14	17	20	24	27	30
12″ brick wall, 3″ air space	8	10	13	15	18	22	25	28
16″ brick wall, 3″ air space	6	8	10	13	16	19	22	25
12″ sandstone wall	16	20	25	28	31	34	37	41
16″ sandstone wall	15	18	21	24	27	30	32	35
20″ sandstone wall	13	15	18	22	25	28	30	33
24″ sandstone wall	8	12	15	18	21	24	26	29
32″ sandstone wall	9	11	14	16	19	22	25	27
36″ sandstone wall	7	9	12	15	17	19	21	24
44″ sandstone wall	5	8	10	12	14	16	18	20
12″ limestone wall	18	22	26	30	34	38	41	44
16″ limestone wall	14	18	22	26	30	34	38	40
20″ limestone wall	15	19	22	25	28	30	33	35
24″ limestone wall	12	14	18	21	24	27	30	33
28″ limestone wall	9	13	16	19	22	25	28	31
36″ limestone wall	8	11	14	16	19	21	24	27
44″ limestone wall	7	9	12	14	16	18	20	22
1½″ pine plank	8	12	15	18	21	24	27	30
2″ pine plank	8	10	13	16	18	20	22	24
2½″ pine plank	7	9	11	14	16	18	20	22
3″ pine plank	5	8	10	12	14	16	18	20
Sheathing and clapboards	12	14	16	18	20	22	24	26
Sheathing, paper and clapboards	8	10	12	14	16	18	20	22
Lath and plaster partition (1 side)	13	20	23	25	28	32	36	40
Lath and plaster partition (both sides)	10	13	16	19	22	25	28	31
Lath and plaster ceiling (1 side)	18	20	22	25	28	32	36	40
¾″ floor, no plaster below	13	16	19	22	25	28	31	34
¾″ floor, lath and plaster below	8	10	13	16	19	22	25	28
1½″ double floor, no plaster	9	11	14	17	20	23	25	27
1½″ double floor, lath and plaster below	5	7	9	11	13	15	17	19
Average frame	15	18	21	24	26	28	31	33
Average frame, back plastered	14	17	20	22	24	26	28	30
Average red brick, back plastered	14	17	20	22	24	26	28	30

If we have good window construction, single sash, you will find (under column 70) 75 heat units (U) loss for each square foot in one hour. Then 36×75=2700 heat units lost through the glass.

If we have average frame construction, you will find (under column 70) 26 heat units loss for each square foot in one hour. Then $244 \times 26 = 6344$ heat units lost through the walls.

We have 195 sq. ft. of floor which will lose heat from the room (70 deg. temperature) to the basement (40 deg. temperature) at the rate due to 30 degrees difference.

If we have 1½-inch double floor without plaster you will find (under column 30) 5 heat units loss for each square foot in one hour. Then $195 \times 5 = 975$ heat units lost through the floor.

Our heat loss calculation now looks like this:

13×15×10=1950×2×1.4=		5460 U
13+15=28×10=280		
2×3×6=	36×75 =	2700 U
	244×26 =	6344 U
13×15=195×5=		975 U
Total heat loss=		15479 U

If the room is very badly exposed, say on the northwest corner of the building, or if subjected to high winds, it is well to add at least 10 per cent to the heat loss.

After determining the total heat loss per hour, the amount of radiation necessary to overcome that loss is found by dividing the total by the number of heat units which each square foot of the radiator intended to be used is capable of delivering. The usual figures are as follows:

Low pressure steam radiators	250 U
Atmospheric or vapor radiators	200 U
Hot water radiators	170 U

Thus if the above room is on a northwest corner and we will use the atmospheric system, our final figures are:

	15479 U
Plus 10%	1548
200)	17027 U
	85 sq. ft.

which may be 17 sections or loops of 3 column 38″ radiation of any standard make or which may be arranged otherwise if more convenient.

Indirect Radiation

To get the proper amount of indirect radiating surface for low pressure steam heating, 50% more surface is necessary than where direct surface is used, so that to warm the room, under above conditions, by indirect radiation 102 square feet of radiation would be required.

How Ends of Pipe Should be Reamed

If the ordinary style of fittings are used on hot water circulating systems, such as are not recessed, all ends of pipes should be

carefully reamed out in a manner as shown in illustration, Fig. 22, and unless the ends of pipes are reamed, taking off at least the burr, there will not only be a large amount of

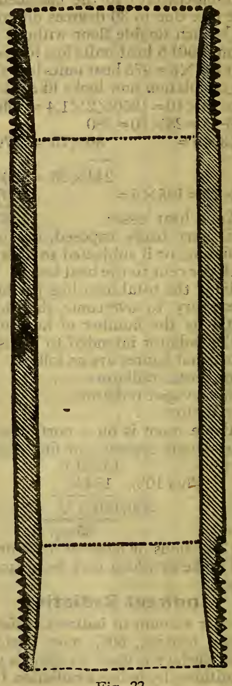


Fig. 22.

friction due to such obstructions, but the capacity of the pipe will be greatly reduced by the burrs contracting the area of the pipes at each end; and

while the average fitter might consider this a small matter, and in a measure a waste of time to ream the ends of pipes, he is working against his own interests if he desires to construct a good, easy, and economical working heating plant. It more than pays, in fact it is a good investment to carefully construct the pipe work of a hot water heating plant, and avoid as much as possible any cause of friction to the movement of the water.

In Fig. 23 is shown the correct method of connecting the expansion tank for a hot water heating system. The supply "A" to the tank should be taken from the return pipe "B" from the radiator, and not from the supply to the radiator. The pipe "C" is an overflow from the tank, and should be carried to the closet tank, or to some other open fixture. The pipe "D" is the vent and is merely to prevent syphonage, but should always be put in and carried not less than 6″ above the overflow pipe.

In Fig. 24 is shown an expansion tank similar to Fig. 23 except that the tank is circulated to prevent freezing. The supply and return pipes are taken from the risers below the floor in order that the tank will interfere as little as possible with the proper working of the radiator.

Amount of Radiation Expansion Tank Will Carry.

Size, Inches.	Capacity, Gallons.	Sq. Ft. of Radiation.	Size, Inches.	Capacity, Gallons.	Sq. Ft. of Radiation.
10x20	8	250	16x36	32	1300
12x20	10	300	16x48	42	2000
12x30	15	500	18x60	66	3000
14x30	20	700	20x60	82	5000
16x30	26	950	22x60	100	6000

Expansion Tanks.

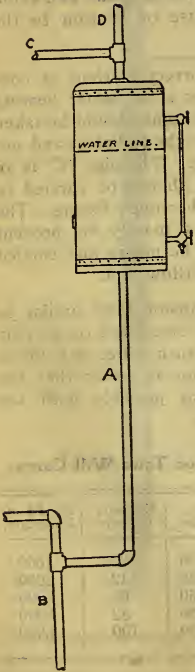


Fig. 23.

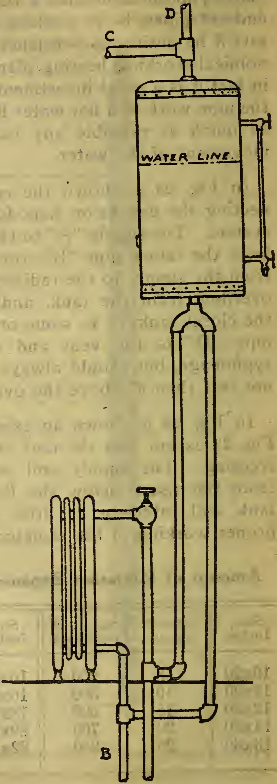


Fig. 24.

Tank Capacity.

Diameter.	Gallons per Foot of Depth.
2 feet	23.5
2 feet 6 inch	36.7
3 feet	52.9
3 feet 6 inch	72.0
4 feet	94.0
4 feet 6 inch	119.0
5 feet	146.9
5 feet 6 inch	177.7
6 feet	221.5
6 feet 6 inch	248.2
7 feet	287.9
7 feet 6 inch	330.5
8 feet	376.0
8 feet 6 inch	424.5
9 feet	475.9
9 feet 6 inch	530.2
10 feet	587.5
11 feet	710.9
12 feet	846.0
13 feet	992.0
14 feet	1151.5
15 feet	1321.9
20 feet	2350.1
25 feet	3672.0
30 feet	5287.7
35 feet	7197.1
40 feet	9400.3

Vertical and Horizontal Tank.

Capacity, Gallons.	Diameter, Inches.	Length, Feet.	Approximate Weight.
66	18	5	220
85	20	5	250
100	22	5	280
120	24	5	320
145	24	6	360
170	24	7	400
180	30	5	480
215	30	6	540
250	30	7	590
300	30	8	640
325	36	6	780
365	36	7	810
420	36	8	880
430	42	6	1150
575	42	8	1400
720	42	10	1650

Air and Water Pressure Tanks.

Diameter. Feet.	Length Feet.	THICKNESS.		Weight.	Capacity, Gallons.
		Shell.	Heads.		
5	20	5/16	3/8	6250	2922
5	25	5/16	3/8	7390	3654
5	30	5/16	3/8	8580	4384
6	20	5/16	1/2	7800	4240
6	28	5/16	1/2	10200	5936
6	36	5/16	1/2	12450	7632
7	20	5/16	1/2	8600	5761
7	28	5/16	1/2	11100	8066
7	36	5/16	1/2	13600	10370
8	24	5/16	1/2	11800	8980
8	30	5/16	1/2	14000	11224
8	36	5/16	1/2	16200	13468

Air and Water Pressure Tanks.

Diameter, Inches.	Length Feet.	Weight	Capacity, Gallons.
24	6	350	140
24	8	420	190
24	10	500	235
30	6	530	220
30	8	650	295
30	10	770	365
30	12	900	440
30	14	1000	515
36	6	750	315
36	8	900	420
36	10	1050	525
36	12	1200	630
36	14	1400	735
36	16	1575	840
42	8	1450	575
42	10	1650	720
42	12	1900	865
42	14	2200	1000
42	16	2400	1150
42	18	2650	1300
42	20	2900	1440
48	10	2200	940
48	12	2550	1130
48	14	2900	1300
48	16	3250	1500
48	18	3600	1700
48	20	3950	1880
48	24	4650	2260

Number of U. S. Gallons in Rectangular Tanks—For one foot in depth

Width of Tank	LENGTH OF TANK.																				
	2 ft.	2 ft. 6 in.	3 ft.	3 ft. 6 in.	4 ft.	4 ft. 6 in.	5 ft.	5 ft. 6 in.	6 ft.	6 ft. 6 in.	7 ft.	7 ft. 6 in.	8 ft.	8 ft. 6 in.	9 ft.	9 ft. 6 in.	10 ft.	10 ft. 6 in.	11 ft.	11 ft. 6 in.	12 ft.
2 ft.	30	37	45	52	60	67	75	82	90	97	105	112	120	127	135	142	150	157	165	172	180
2 ft. 6 in.	....	47	56	65	75	84	94	103	112	122	131	140	150	159	168	178	187	196	206	215	224
3 ft.	....	....	67	79	90	101	112	123	135	146	157	168	180	191	203	213	224	236	247	258	269
3 ft. 6 in.	....	....	....	92	105	118	131	144	157	170	183	196	209	223	236	249	262	275	288	301	314
4 ft.	....	....	....	....	120	135	150	165	180	194	209	224	239	254	269	284	299	314	329	344	359
4 ft. 6 in.	....	....	....	....	....	151	168	185	202	219	236	252	269	286	303	320	337	353	370	387	404
5 ft.	....	....	....	....	....	....	187	206	224	243	262	281	299	318	337	355	374	393	411	430	449
5 ft. 6 in.	....	....	....	....	....	....	....	226	247	267	288	309	329	350	370	391	411	432	453	473	494
6 ft.	....	....	....	....	....	....	....	....	269	292	314	337	359	381	404	426	449	471	494	516	539
6 ft. 6 in.	....	....	....	....	....	....	....	....	....	316	340	365	389	413	438	462	486	511	535	559	583
7 ft.	....	....	....	....	....	....	....	....	....	....	367	393	419	445	471	497	524	550	576	602	628
7 ft. 6 in.	....	....	....	....	....	....	....	....	....	....	....	421	449	477	505	533	561	589	617	645	673
8 ft.	....	....	....	....	....	....	....	....	....	....	....	....	479	509	540	569	598	628	658	688	718
8 ft. 6 in.	....	....	....	....	....	....	....	....	....	....	....	....	....	540	572	604	636	668	699	731	763
9 ft.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	606	640	673	707	741	774	808
9 ft. 6 in.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	675	711	746	782	817	853
10 ft.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	748	785	823	860	898
10 ft. 6 in.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	825	864	903	943
11 ft.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	905	946	987
11 ft. 6 in.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	989	1032
12 ft.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1077

Outside Diameter of Standard Wrought Iron, Steam, Gas and Water Pipe. From 1-8 to 10 Inches.

Fig. 25.

Size of pipe...........	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Outside diam. of pipe..	$\frac{40}{100}$	$\frac{54}{100}$	$\frac{67}{100}$	$\frac{84}{100}$	$1\frac{5}{100}$
Size of pipe...........	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Outside diam. of pipe..	$1\frac{31}{100}$	$1\frac{66}{100}$	$1\frac{90}{100}$	$2\frac{37}{100}$	$2\frac{87}{100}$
Size of pipe...........	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
Outside diam. of pipe..	$3\frac{50}{100}$	$4\frac{00}{100}$	$4\frac{50}{100}$	$5\frac{00}{100}$	$5\frac{56}{100}$
Size of pipe...........	6	7	8	9	10
Outside diam. of pipe..	$6\frac{62}{100}$	$7\frac{62}{100}$	$8\frac{62}{100}$	$9\frac{68}{100}$	$10\frac{77}{100}$

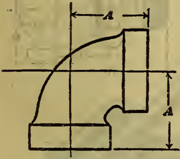
Properties of Saturated Steam.

1	2	3	4	5	6	7	8	9
Gauge Pressure in Pounds per Sq. Inch	Temperature in ° F.	Total Heat in Heat Units from Water at 32° F.	Heat Units in Liquid from 32° F.	Heat of Vaporization in Heat Units	Density or Weight of 1 Cu. Foot in Pounds	Volume of 1 pound in Cubic Feet	Weight of 1 Cubit Foot of Water	Factor of Equiv'l't Ev-ap'n from and at 212° F.
0	212.00	1146.6	180.8	965.8	0.03760	26.600	*{ 59.76 59.64	1.0000
10	239.36	1154.9	208.4	946.5	0.06128	16.320	59.04	1.0086
20	258.68	1160.8	227.9	932.9	0.08439	11.850	58.50	1.0147
30	273.87	1165.5	243.2	922.3	0.10700	9.347	58.07	1.0196
40	286.54	1169.3	255.9	913.4	0.12920	7.736	57.69	1.0235
50	297.46	1172.6	266.9	905.7	0.15120	6.612	57.32	1.0269
55	302.42	1174.2	271.9	902.3	0.16210	6.169	57.22	1.0286
60	307.10	1175.6	276.6	899.0	0.17290	5.784	57.08	1.0300
65	311.54	1176.9	281.1	895.8	0.18370	5.443	56.95	1.0314
70	315.77	1178.2	285.6	892.7	0.19450	5.142	56.82	1.0327
75	319.80	1179.5	289.8	889.8	0.20520	4.873	56.69	1.0341
80	323.66	1180.6	293.8	886.9	0.21590	4.633	56.59	1.0352
85	327.36	1181.8	297.7	884.2	0.22650	4.415	56.47	1.0365
90	330.92	1182.8	301.5	881.5	0.23710	4.218	56.36	1.0375
95	334.35	1183.9	305.0	879.0	0.24770	4.037	56.25	1.0386
100	337.66	1184.9	308.5	876.5	0.25830	3.872	56.18	1.0397
105	340.86	1185.9	311.8	874.1	0.26890	3.720	56.07	1.0407
110	343.95	1186.8	315.0	871.8	0.27940	3.580	55.97	1.0417
115	346.94	1187.7	318.2	869.6	0.28980	3.452	55.87	1.0426
120	349.85	1188.6	321.2	867.4	0.30030	3.330	55.77	1.0435
125	352.68	1189.5	324.2	865.3	0.31070	3.219	55.69	1.0444
130	355.43	1190.3	327.0	863.3	0.32120	3.113	55.58	1.0452
135	358.10	1191.1	329.8	861.3	0.33150	3.017	55.52	1.0461
140	360.70	1191.9	332.5	859.4	0.34200	2.924	55.44	1.0469
145	363.25	1192.8	335.2	857.5	0.35240	2.838	55.36	1.0478
150	365.73	1193.5	337.8	855.7	0.36290	2.756	55.29	1.0486

*Formula observed.

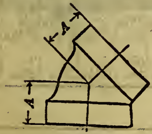
Measurements of Elbows and 45° Elbows from 1¼ in. to 8 in. Inclusive.

Extreme caution must be exercised in allowing for thread.



90° Long Turn Elbows.

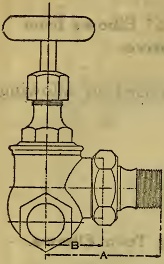
Size.. Inches	1¼	1½	2	2½	3	4	5	6	7	8
Dimen. A In.	2¼	2½	3 1/16	3 11/16	4¼	5 3/16	6⅛	7⅛	8⅛	9



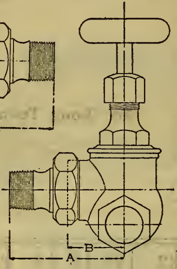
45° Elbows.

Size Inches	1¼	1½	2	2½	3	4	5	6	7	8
Dimen. A In.	1⅜	1 7/16	1¾	2 1/16	2⅜	2¾	3 3/16	3½	3⅞	4 3/16

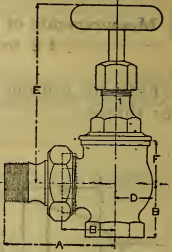
Measurements of Corner and Angle Valves



Right Hand



Left Hand



Dimensions of Angle Radiator Valves

Size	½	¾	1	1¼	1½	2	2½	3
A—Centre to end of union	2 13/16	3 5/16	3¾	4	4½	4¾	5⅞	6⅞
B—Centre to face, screwed end	1⅜	1½	1 13/16	2 1/16	2¼	2 13/16	3¼	4¼
D—Radius of body	⅞	1 1/16	1¼	1½	1¾	2¼	2 11/16	3¼
E—Centre of outlet to top of hand wheel	4¾	5½	5½	6½	7	8	9	9½
F—Centre to top of body	1	1 3/16	1 5/16	1½	1 11/16	2 1/16	2 5/16	2⅞

Dimensions of Offset Corner Valves

Size	½	¾	1	1¼	1½	2
A—Centre to end of union	3	3 7/16	3¾	4⅛	4 11/16	5⅝
B—Centre to face, screwed end	1½	1⅝	2	2⅛	2 9/16	3⅛
C—Centre of outlet to centre of inlet	¾	1	1 5/32	1 3/16	1½	1 11/16
D—Radius of body	⅞	1 1/16	1¼	1½	1¾	2 3/16
E—Centre of outlet to top of hand wheel	4½	5	5⅜	6¼	7	7½
F—Centre of outlet to top of body	⅞	1 1/16	1 3/16	1 7/16	1½	2⅛

A few illustrations showing most successful methods of taking connections off mains and risers for hot water circulation, also showing branches connecting to radiators.

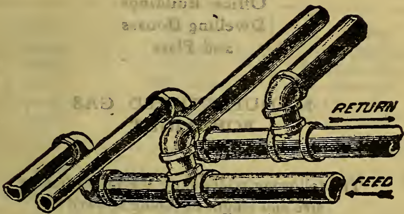


Fig. 25.

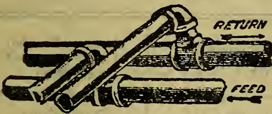


Fig. 26.

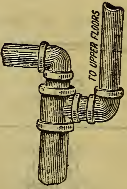


Fig. 27

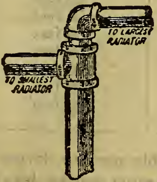


Fig. 28.

GAS FITTERS' RULES

Office Buildings
Dwelling Houses
and Flats

MANUFACTURED GAS FOR LIGHT

The following tables show the proportionate size and length of tubing allowed:

Size of Tubing.	Greatest Length Allowed.	Greatest Number of ⅜ in. Openings Allowed.
⅜ inch	20 feet	2 openings
½ inch	30 feet	3 openings
¾ inch	60 feet	10 openings
1 inch	70 feet	15 openings
1¼ inch	100 feet	30 openings
1½ inch	150 feet	60 openings
2 inch	200 feet	100 openings
2½ inch	200 feet	000 openings
3 inch	300 feet	000 openings

Drops in double parlors, large rooms and halls of office buildings must not be less than ½ inch.

Stores, Hospitals, Schools, Factories, Etc.

MANUFACTURED GAS FOR LIGHT

Size of Tubing.	Greatest Length Allowed.	Greatest Number of ½ in. Openings Allowed.
½ inch.	20 feet.	1 opening.
¾ inch.	60 feet.	8 openings.
1 inch.	70 feet.	12 openings.
1¼ inch.	100 feet.	20 openings.
1½ inch.	150 feet.	35 openings.
2 inch.	200 feet.	50 openings.

For stores the running line to be full size to the end of last opening.

All drops to be ½ inch, with set not less than 4 inches.

20 feet of ⅜ inch pipe allowed only for bracket lights.

Building Services.

In running service pipe from front wall to meters the following rules will apply:

Size of Opening.	Greatest Length Allowed.	Greatest Number of ¾ in. Openings Allowed.
1 inch.	70 feet.	1 opening.
1¼ inch.	100 feet.	3 openings.
1½ inch.	150 feet.	5 openings.
2 inch.	200 feet.	8 openings.

All openings in service must be equal to the size of riser, which in no case must be less than ¾ inch.

For Gas Engines.

Size of Engine.	Size of Opening.	Greatest Length Allowed.
1 H. P.	1 inch	60 feet.
2 H. P.	1¼ inch	70 feet.
5 H. P.	1½ inch	100 feet.
7 H. P.	1½ inch	100 feet.
12 H. P.	2 inch	140 feet.

Materials for Brickwork of Regular Tubular Boilers

Single Setting.

Boilers. In. Ft.	Common Brick.	Fire Brick.	Sand, Bushels.	Cement. Barrels.	Fire Clay. Lbs.	Lime' Bbls.
30 x 8	5200	320	42	5	192	2
30 x 10	5800	320	46	5½	192	2¼
36 x 8	6200	480	50	6	288	2½
36 x 9	6600	480	53	6½	288	2¾
36 x 10	7000	480	56	7	288	3
36 x 12	7800	480	62	8	288	3¼
42 x 10	10000	720	80	10	432	4
42 x 12	10800	720	86	11	432	4¼
42 x 14	11600	720	92	11¾	432	4⅛
42 x 16	12400	720	99	12½	432	5
48 x 10	12500	980	100	12½	590	5¼
48 x 12	13200	980	108	13½	590	5½
48 x 14	14200	980	116	14½	590	5¾
48 x 16	15200	980	124	15½	590	6
54 x 12	13800	1150	108	13¾	690	5½
54 x 14	14900	1150	117	15	690	6
54 x 16	16000	1150	126	16	690	6¼
60 x 10	13500	1280	108	13½	768	5½
60 x 12	14800	1280	118	14¾	768	6
60 x 14	16100	1280	128	16	768	6½
60 x 16	17400	1280	140	17½	768	7
60 x 18	18700	1280	148	18¾	768	7½
66 x 16	19700	1400	157	19¾	840	8
72 x 16	20800	1550	166	20¾	930	8½

Materials for Brickwork of Regular Tubular Boilers.

Two Boilers in a Battery.

Boilers. In. Ft.	Common Brick.	Fire Brick.	Sand, Bushels.	Cement, Barrels.	FireClay, Lbs.	Lime, Barrels
30 x 8	8900	640	70	9	384	3½
30 x 10	9600	640	76	9½	384	4
36 x 8	10500	960	84	10½	576	4¼
36 x 9	11100	960	88	11	576	4½
36 x 10	11800	960	95	12	576	4¾
36 x 12	13000	960	104	13	576	5¼
42 x 10	17500	1440	140	17½	864	7
42 x 12	18600	1440	148	18½	864	7½
42 x 14	19900	1440	159	20	864	8
42 x 16	21200	1440	168	21	864	8½
48 x 10	21400	1960	170	21½	1180	8¾
48 x 12	22300	1960	178	22⅓	1180	9
48 x 14	23900	1960	190	24	1180	9½
48 x 16	25100	1960	200	25	1180	10
54 x 12	23300	2300	186	23⅓	1380	9⅓
54 x 14	24800	2300	198	25	1380	10
54 x 16	26300	2300	210	26⅓	1380	10½
60 x 10	22600	2560	180	22½	1536	9
60 x 12	24800	2560	198	25	1536	10
60 x 14	26800	2560	214	27	1536	10¾
60 x 16	28900	2560	230	29	1536	11½
60 x 18	31000	2560	248	31	1536	12½
66 x 16	33100	2800	264	33	1680	13¼
72 x 16	34000	3100	272	34	1860	13¾

Materials for Brickwork of Firebox Boilers 12-inch Walls

Boilers In. Ft.	Brick	Sand, Bushels	Cement, Barrels	Lime, Barrels
30 x 6½......	2400	20	2½	1
30 x 7½......	2650	21	2½	1
30 x 8½......	2900	23	2¾	1¼
36 x 7½......	3150	25	3	1½
36 x 9	3550	28	3½	1¾
36 x 10½......	4000	31	4	2
42 x 8½......	4000	31	4	2
42 x 10	4600	38	5	2¼
42 x 11½......	5100	41	5½	2¼
48 x 10½......	4900	40	5½	2½
48 x 12	5400	43	5¾	2½
48 x 13½......	5800	46	6	2¾
54 x 14	6900	54	6¾	3
54 x 16½......	7500	59	7¾	3½

Materials for Brickwork of Firebox Boilers 9-inch Walls

Boilers In. Ft.	Brick	Sand, Bushels	Cement, Barrels	Lime, Barrels
30 x 6½......	1640	14	1½	1
30 x 7½......	1820	15	1¾	1
30 x 8½......	1980	16	2	1¼
36 x 7½......	2240	18	2¼	1½
36 x 9	2520	20	2¾	1¾
36 x 10½......	2870	23	3	2
42 x 8½......	2870	23	3	2
42 x 10	3400	27	3½	2¼
42 x 11½......	3800	30	4	2½
48 x 10½......	3600	29	3¾	2¼
48 x 12	3860	30	4	2½
48 x 13½......	4140	33	4½	2¾
54 x 14	5150	41	5½	3
54 x 16½......	5550	43	5¾	3¼

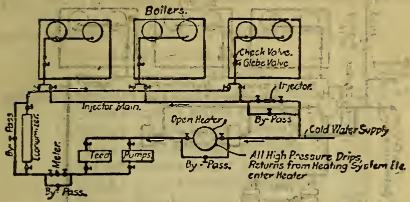


Fig. 29. Feed Piping with Open Heater.

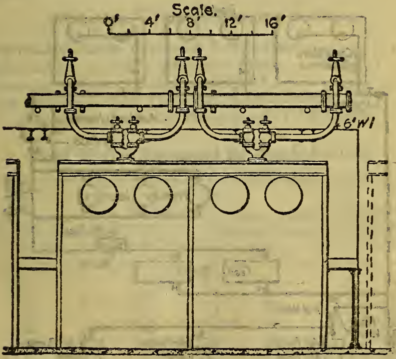


Fig. 30. Elevation of Boiler Piping.

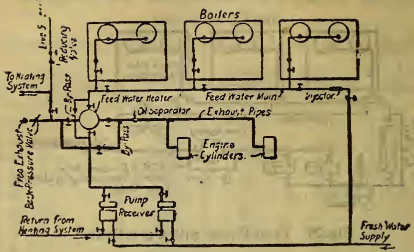


Fig. 31. Exhaust and Feed Piping for Non-Condensing Plant.

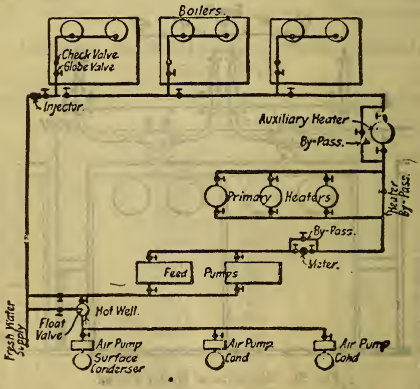


Fig. 32. Feed Piping for Condensing Plant.

Horse Power of an Engine.

A equals Area of piston in square inches.
P equals Mean pressure of the steam on the piston per square inch.
V equals Velocity of piston per minute in feet.

$$\text{Then H. P. equals } \frac{a \times p \times v}{33000}$$

The mean pressure in the cylinder when cutting off at
¼ Stroke equals boiler pressure × .597
⅓ Stroke equals boiler pressure × .670
⅜ Stroke equals boiler pressure × .743
½ Stroke equals boiler pressure × .847
⅝ Stroke equals boiler pressure × .919
⅔ Stroke equals boiler pressure × .937
¾ Stroke equals boiler pressure × .966
⅞ Stroke equals boiler pressure × .992

To find the weight of the rim of the fly wheel for an engine:

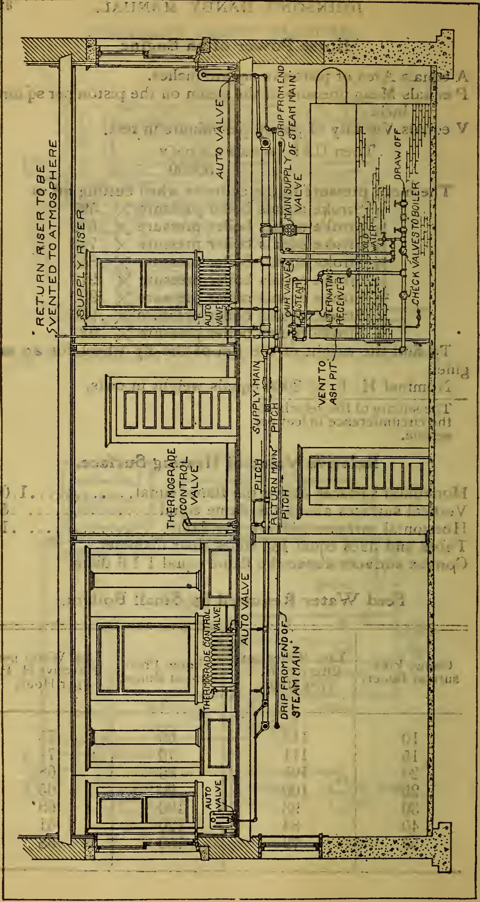
$$\frac{\text{Nominal H. P.} \times 2000}{\text{The square of the velocity of the circumference in feet per second.}} \text{ equals weight in cwts.}$$

Relative Value of Heating Surface.

Horizontal surfaces above the flame equal............1.00
Vertical surfaces above the flame equal.............. .50
Horizontal surfaces beneath the flame................ .10
Tubes and flues equal 1¼ times their diameter.
Convex surfaces above the flame equal 1 1-6 diam.

Feed Water Required by Small Boilers.

Gauge Pressure at Boiler.	Lbs. Water per Effective H. P. per Hour.	Gauge Pressure at Boiler.	Lbs. Water per Effective H. P. per Hour.
10	118	60	75
15	111	70	71
20	105	80	68
25	100	90	65
30	93	100	63
40	84	120	61
50	79	150	58



Thermograde System of Heat Modulation

The above cut illustrates the Thermograde System of steam heating, as manufactured by the Consolidated Engineering Company. Steam is distributed to different units of radiation through a system of mains in the ordinary manner and water of condensation is returned to the boiler through an independent system of return mains.

Each unit of radiation is equipped with a Thermograde valve at the supply end and an auto valve at the return. The Thermograde valve is connected at the top of the radiator and is provided with a graduated dial, indicating the portion of the radiator to be heated. The valve is so constructed that it may be adjusted to give the proper graduation to different size radiators supplied with the same size valve.

The auto valve is a trap of the thermostatic type which permits of the free passage of air and water of condensation, but closes against the passage of steam. When in operation the valve automatically assumes a position off the seat, directly proportional to the quantity of steam condensed in the radiator. The return system is vented to the atmosphere through the return risers.

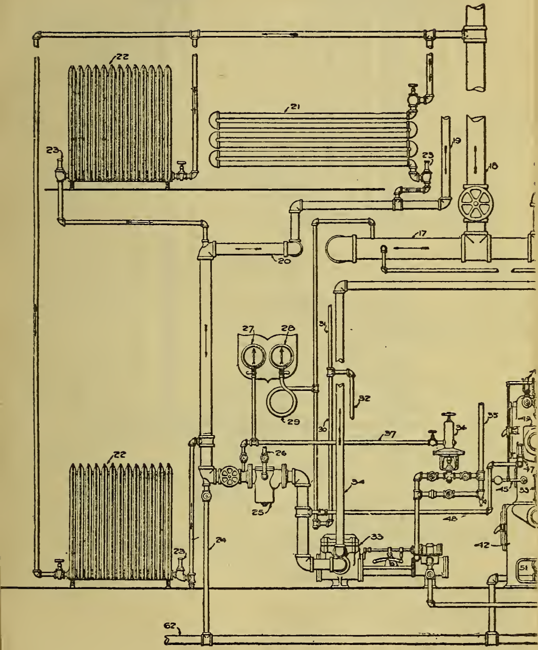
When operating under normal conditions with about one pound pressure on the boiler the head of water from the water line of the boiler to the return main is sufficient to force the water into the boiler, but when the pressure is increased, either intentionally or through inattention, the water of condensation flows into the alternating receiver, the air being discharged through a vent pipe provided for the purpose.

When the receiver fills with water the float controlled valve is reversed, closing the air vent and admitting steam from the boiler. This closes the check valve on the heating system, equalizing the pressure between the receiver and the boiler and water flows into the boiler by gravity. When the receiver empties, the position of the valve is again changed and the action repeated.

Key to Diagram Fig. 35.

Illustrating the Webster System of Steam Circulation for Heating Purposes.

1. Steam engine.
2. Live steam supply to engine.
3. Exhaust steam from engine.
4. Drip.
5. Check-valve.
6. Grease extractor.
7. Water leg.
8. Anti-syphonage vent.
9. Check-valve.
10. Back-pressure valve.
11. Waste exhaust steam to atmosphere.
12. Exhaust steam supply to feed-water heater.
13. Exhaust steam supply to house heating main.
14. Live steam supply to house heating main.
15. Pressure-reducing valve.
16. Connection from house heating main communicating pressure to diaphragm of pressure-reducing valve.
17. House heating main.
18. Heating riser.
19. Return.
20. Return main.
21. Heating coil.
22. Radiators.
23. Thermostatic return valves.
24. Drip.
25. Dirt strainer.
26. Cold water supply.
27. Return vaccum gauge.
28. Supply pressure gauge.
29. Water seal.
30. Water leg.
31. Vent.
32. Drip.
33. Return pumps.
34. Discharge to return pump
35. Live steam supply to return pump.
36. Differential regulator or vacuum governor.
37. Connection from return to differential regulator.
38. Return tank.
39. Vent.
40. }
41. } Return and seal to feed-water heater.
42. Feed-water heater.
43. Cold water supply to feed-water heater.
44. Automatic valve.
45. Float-operated lever.
46. Safety valve.
47. Thermostatic relief valve.
48. Relief connection to return pipe.
49. Grease extractor.
50. Greasy waste to sewer.
51. Overflow and drain from feed-water heater.
52. Feed-water to boiler feed pump.
53. Feed-water thermometer.
54. Boiler feed pump.
55. Feed-water to boiler.
56. Live steam supply to boiler feed pump.
57. Exhaust steam from return pump.
58. Exhaust steam from boiler feed pump.
59. Drip.
60. Check-valve.
61. Exhaust steam pumps to feed-water heater.
62. Waste drips to sewer.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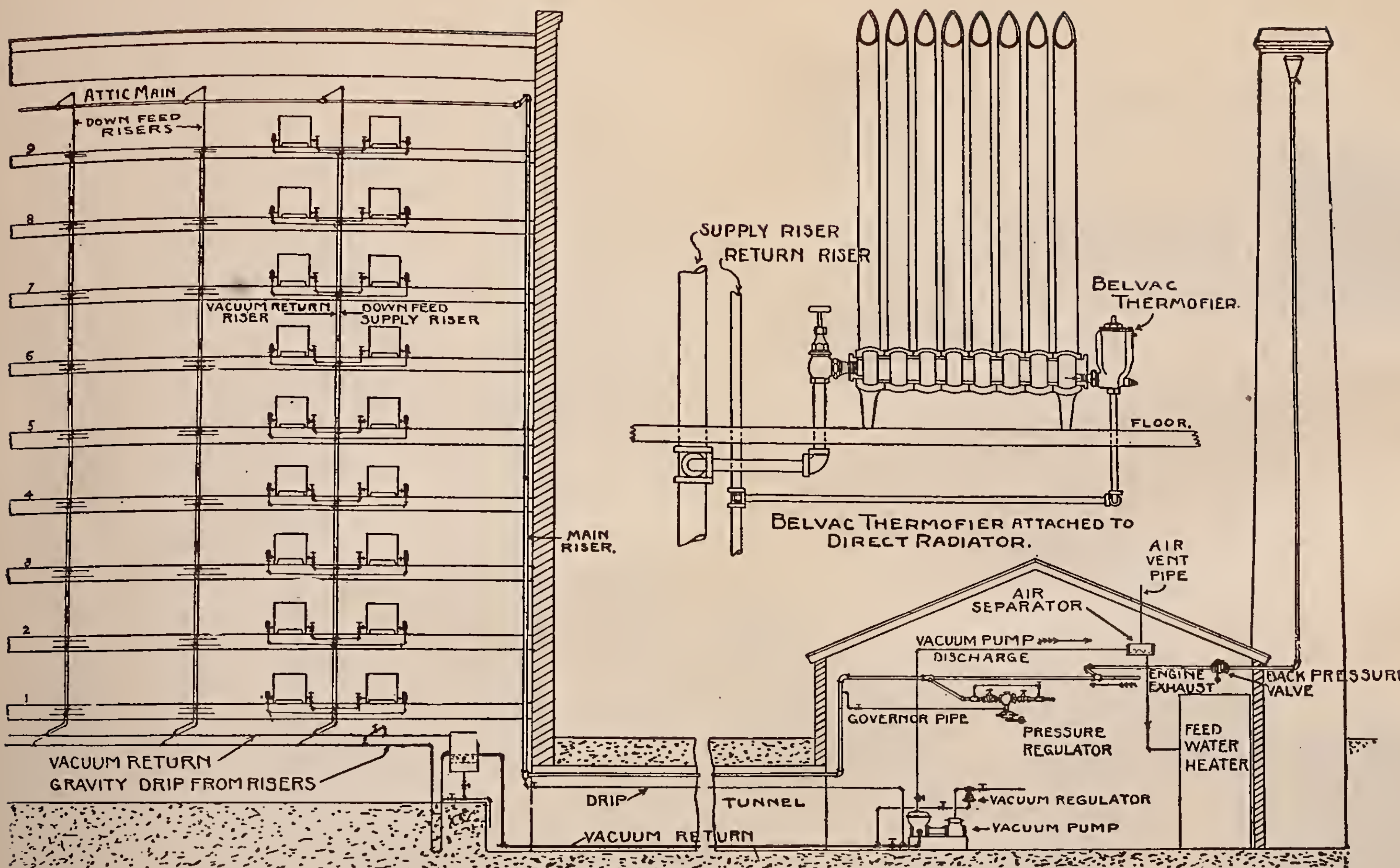
The Webster



SECTIONAL DIAGRAM
GIVING GENERAL VIEW OF INSTALLATION IN THE "LESSING ANNEX."
EVANSTON AVE & SURF ST., CHICAGO.

VAN AUKEN SYSTEM OF VACUUM HEATING,
WITH
BELVAC THERMOFIERS.

Fig. 34

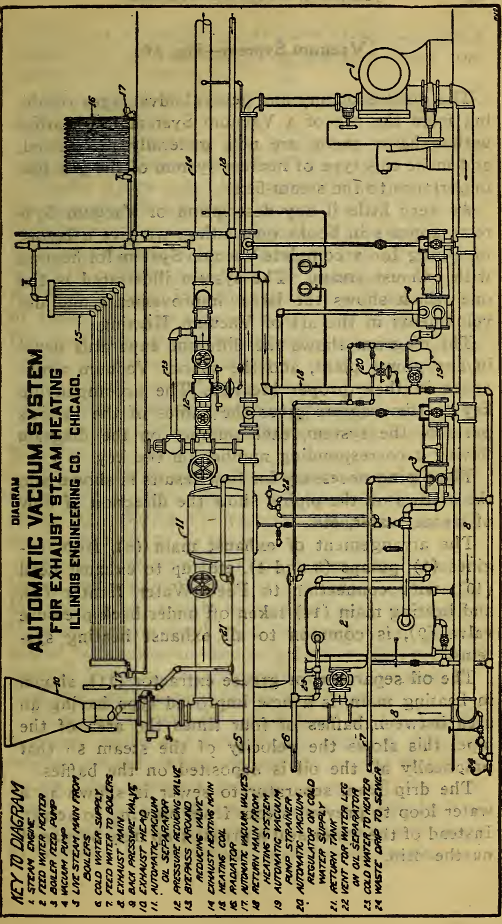
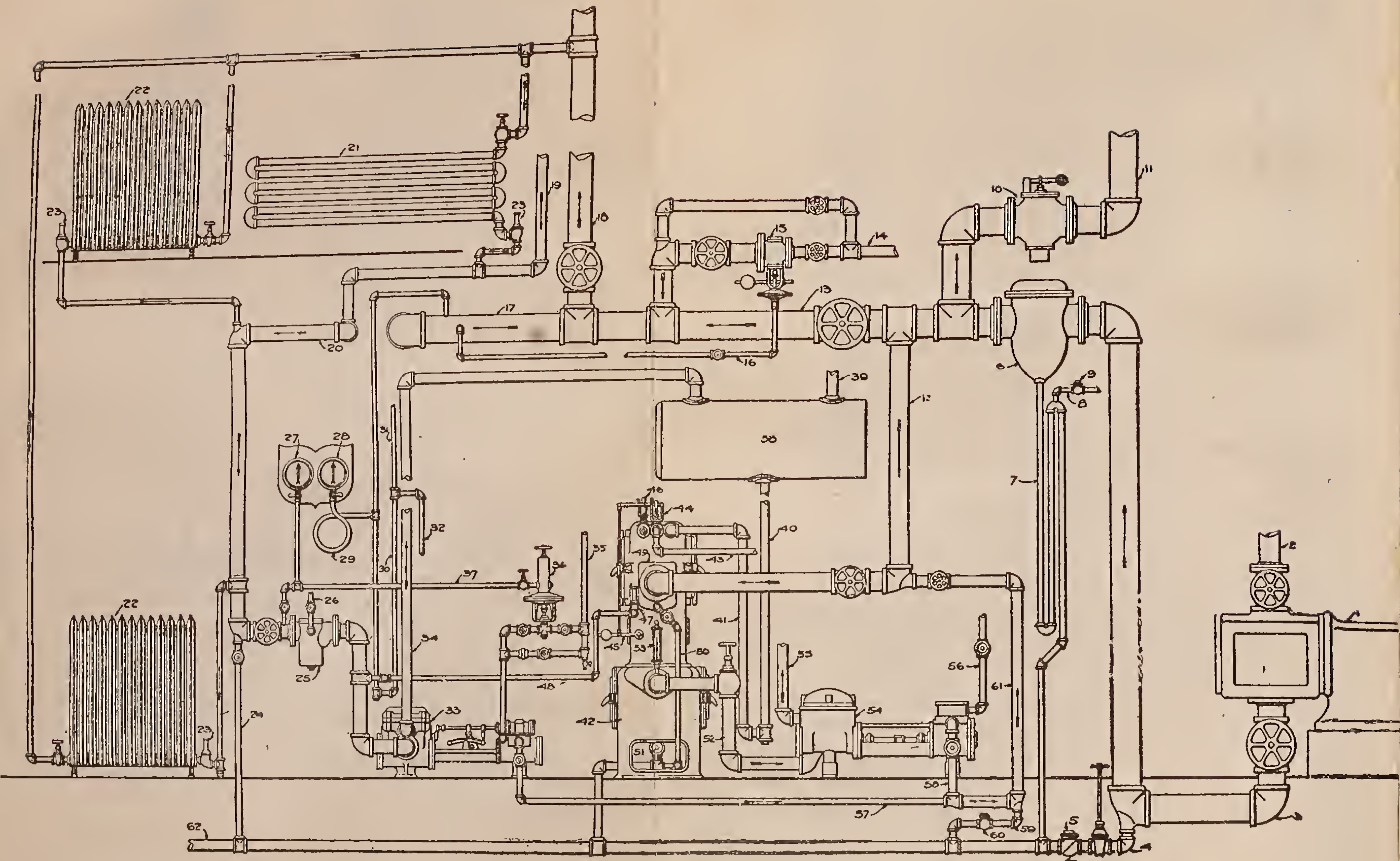


DIAGRAM
AUTOMATIC VACUUM SYSTEM
FOR EXHAUST STEAM HEATING
ILLINOIS ENGINEERING CO. CHICAGO.
KEY TO DIAGRAM
1 STEAM ENGINE
2 FEED WATER HEATER
3 BOILER FEED PUMP
4 VACUUM PUMP
5 LIVE STEAM MAIN FROM BOILERS
6 COLD WATER SUPPLY
7 FEED WATER TO BOILERS
8 EXHAUST MAIN
9 BACK PRESSURE VALVE
10 EXHAUST HEAD
11 AUTOMATIC VACUUM OIL SEPARATOR
12 PRESSURE REDUCING VALVE
13 BYEPASS AROUND REDUCING VALVE
14 EXHAUST HEATING MAIN
15 HEATING COIL
16 RADIATOR
17 AUTOMATIC VACUUM VALVES
18 RETURN MAIN FROM HEATING SYSTEM
19 AUTOMATIC VACUUM PUMP STRAINER
20 AUTOMATIC VACUUM REGULATOR ON COLD WATER SUPPLY
21 RETURN TANK
22 VENT FOR WATER LEG ON OIL SEPARATOR
23 COLD WATER TO HEATER
24 WASTE DRIP TO SEWER

Fig. 36.



The Webster System.—Fig. 35

Vacuum System—Fig. 36.

The great economy and general advantages resulting from the use of a Vacuum System for heating with exhaust steam are now generally recognized, and make this type of heating system of the greatest importance to the steam-fitter.

As very little if any description of Vacuum Systems appears in books on heating, we give a layout of piping for a complete Vacuum System for heating with exhaust steam. The system illustrated is the one which shows the latest improvements and developments in the art of Vacuum Heating.

The diagram shows the different apparatus usual in any power plant, and the special Vacuum appliances in their proper location. The accompanying key to the diagram gives the names of the various parts of the system, each number on the diagram having a corresponding number on the key.

The piping necessary for best results is shown and the arrows on the piping show the direction of flow of steam, water, etc.

The arrangement of exhaust main (8), from engines (1), pumps (3 and 4), etc., up to exhaust head (10), with connection to Feed Water Heater (2), and heating main (14) taken off under back pressure valve (9), is common to all exhaust heating systems.

The oil separator, or grease extractor (11), shown in heating main, is a new improved type having an area between baffles of four times the area of the pipe, this slows the velocity of the steam so that practically all the oil is deposited on the baffles.

The drip from separator to sewer is shown as a water loop to prevent steam from blowing to sewer. Instead of the water seal a grease trap may be placed on the drip.

(12) is a connection to the live steam through a reducing valve, the controlling pressure being connected to the heating main (14).

(13) is a byepass around reducing valve for emergency use.

From heating main (14) risers are taken off to supply the radiators or coils (15 or 16).

On the return ends of all units of radiation (15 and 16), are placed automatic vacuum valves of proper capacity for the size of each unit. These valves permit the vacuum in the returns to pull all air and water of condensation from the radiators and assist the flow of steam into the radiators without the loss of steam into the return lines. The valves are of the float type which immediately open to full capacity as soon as the body of valve is filled with water. They are automatic, require no adjustment, and are provided with a strainer to keep scale out of the valve, they also have a byepass with lock shield and key.

All the returns from the automatic vacuum valves unite into a return main (18) running to vacuum pump (4). Before the vacuum pump an automatic pump strainer (19) is placed.

This strainer prevents scale, filings, etc., from entering pump cylinder, and it also has a connection for cold water which is sprayed over the screen through a spray head. On this cold water pipe is placed the automatic vacuum governor (20), the controlling pressure is connected to the vacuum return (18) and the operation is as follows:

When the vacuum in (18) is low, say 5 inches, the governor opens and admits cold water to assist in holding vacuum, when the vacuum gets up to say 12 inches, the governor entirely closes off the cold water. The weights on governor are adjusted so that valve may be set to open or close on any range of vacuum. In this manner any desired vacuum can

be maintained, and the usual constant flow of cold water which floods the heater to the sewer is prevented.

At the bottom of (18) is shown a byepass connection to sewer, so that plant can be operated as a gravity system temporarily if vacuum pump or heater are being repaired.

The discharge pipe from vacuum pump to heater is shown running into a return tank (21), with an air vent to roof. With a closed heater the feed pump pulls from the return tank and pumps to boilers through heater. With an open heater the tank may be small, as it simply serves the purpose of liberating air from the feed water, the water loop shown between air vent tank and heater prevents steam from escaping from heater.

With such a vacuum system exhaust steam may be circulated to heat groups of buildings several thousand feet from the power house, and without back pressure on the engines. Back pressure which is necessary for circulation in a gravity system causes loss; with 80 lbs. boiler pressure, an engine having 5 lbs. back pressure will use about 15% more steam than it will without the back pressure.

In addition to this fuel saving, a Vacuum System which removes air and water of condensation from the radiation gives perfect circulation without water hammer, air binding, or water logging of the heating system.

The many advantages secured by the use of an improved Vacuum System are so important that very few heating plants of any size are now installed without a Vacuum System.

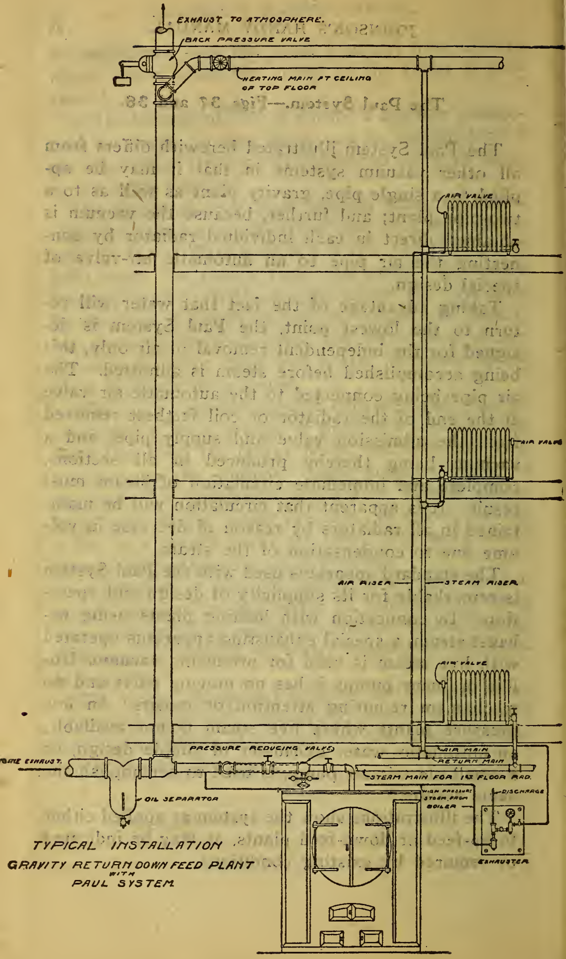
The Paul System.—Figs. 37 and 38.

The Paul System illustrated herewith differs from all other vacuum systems in that it may be applied to a single pipe, gravity plant as well as to a two-pipe plant; and further, because the vacuum is obtained direct in each individual radiator by connecting the air pipe to an automatic air-valve of special design.

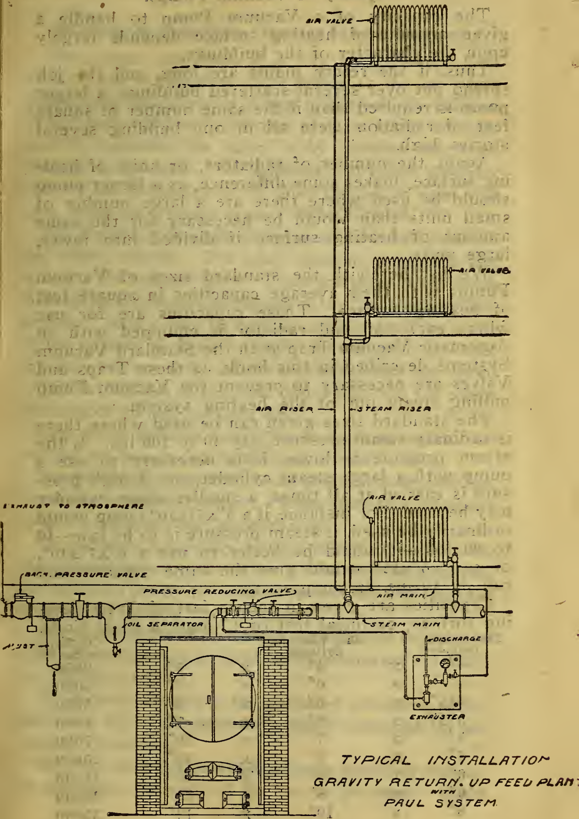
Taking advantage of the fact that water will return to the lowest point, the Paul System is designed for the independent removal of air only, this being accomplished before steam is admitted. The air pipe being connected to the automatic air valve at the end of the radiator or coil farthest removed from the admission valve and supply pipe, and a vacuum being thereby produced in all sections, complete and immediate circulation of steam must result. It is apparent that circulation will be maintained in all radiators by reason of decrease in volume due to condensation of the steam.

The standard apparatus used with the Paul System is remarkable for its simplicity of design and operation. In connection with heating plants using exhaust steam, a special exhausting apparatus operated with live steam is used for producing vacuum. Unlike ordinary pumps it has no moving parts and no mechanism requiring attention or repairs. In low pressure plants where live steam is not available, an automatic water exhauster of simple design, or a small electric air pump, is used to accomplish the same results.

The illustrations show the system as applied either to up-feed or down-feed plants, as may be indicated or required by existing conditions.



Paul System Fig. 37.



Paul System Fig. 38

Capacity of Vacuum Pumps.

The capacity of a Vacuum Pump to handle a given amount of heating surface depends largely upon the character of the buildings.

Thus, if the return mains are long, and the job spread out over several scattered buildings, a larger pump is required than if the same number of square feet of radiation were all in one building several stories high.

Again, the number of radiators, or units of heating surface, makes some difference, as a larger pump should be used where there are a large number of small units than would be necessary for the same amount of heating surface if divided into fewer, large units.

We list herewith the standard sizes of Vacuum Pumps with their average capacities in square feet of heating surface. These capacities are for use where each coil and radiator is equipped with an Automatic Vacuum Trap as in the Standard Vacuum Systems described in this book, as these Traps and Valves are necessary to prevent the Vacuum Pump pulling steam out of the heating system.

The standard sizes given can be used where there is ordinary steam pressure, say 40 to 100 lbs. If the steam pressure is lower it is necessary to use a pump with a large steam cylinder, or, if high pressure is carried at all times, a smaller steam cylinder may be used. For instance, if a 5"x7"x10" pump would ordinarily be used, if steam pressure is to be low—10 to 20 lbs.—it would be better to use a 6"x7"x10", or a 6"x6"x12" would give the same capacity and run on 10 lbs. steam pressure.

Capacities are given in square feet of direct heating surface, or lineal feet of 1" pipe in Blast Coils.

Dia. Steam Cylinder.		Dia. Vaccuum Cylinder			Capacity in Sq. Ft.
4"	x	4"	x	5"	2000
4"	x	6"	x	7"	3000
4½"	x	6"	x	8"	5000
5½"	x	8"	x	7"	6000
5"	x	7"	x	10"	7500
5"	x	8"	x	10"	10000
6"	x	9"	x	10"	15000
6"	x	8"	x	12"	20000
8"	x	10"	x	12"	35000
8"	x	12"	x	12"	50000

Courtesy of American District Steam Company

This system uses steam at a very low pressure. Each radiator has a graduated valve placed at the top which permits only enough steam to pass to *partly* fill the radiator.

The amount of heat in the room is varied to suit the occupant by operating the valve, or by changing the steam pressure in the main. The radiators and return pipes are open to the atmosphere at all times through an open vent pipe, hence the system's name—"ATMOSPHERIC."

The greatest boiler pressure required is one-half pound in the coldest weather. The usual operating pressure is five ounces at the radiator valve. Under this pressure the steam flows into the radiator and expands in the top to atmospheric pressure. Here it loses its heat and trickles down the inside of the radiator as water. Further heat is given up, until the water falls out of the radiator return pipe only luke warm.

The air falls out of the same return pipe into the return and escapes through the open vent.

Only direct radiators having inside passages both at the top and the bottom (hot water type) should be used.

The graduated valve should not be used on indirect radiators or on direct-indirect radiators. These should be connected up in the usual two pipe standard way.

The radiators are usually set large enough to do the work when eighty per cent of the surface is filled with steam, leaving the remaining twenty per cent to abstract the heat from the water before it flows into the return.

This is accomplished by figuring the radiation required for a low pressure steam system and adding one-quarter or twenty-five per cent to it.

The extreme accuracy of the graduated valve gives perfect control of the room temperature which saves fuel by preventing overheating.

The extra surface in the radiator gives great fuel economy by preventing the waste of the heat in the water. It also

provides a safeguard for abnormally cold weather, as the radiator can be entirely filled with steam by raising the steam pressure above the normal operating point.

Fig. 7

Where steam is received from an outside source, the heating company usually extends the service pipe with a gate valve through the building wall ready for extension by others.

The contractor then installs a pressure regulating valve and extends the supply and return piping to the radiators as shown in the illustration.

Water collecting in the supply main is drained through a deep seal into the bottom of a receiver which has an overflow to the meter. A gauge to indicate the pressure is placed on the steam main at a convenient point. Returns are run to the top of the receiver. The water falls into the receiver and overflows into the meter. The air escapes through an open vent pipe from the top of the receiver, which is carried up fifteen feet above the return. The discharge from the meter is connected to sewer, to tank, or to return main in the street as directed by the heating company.

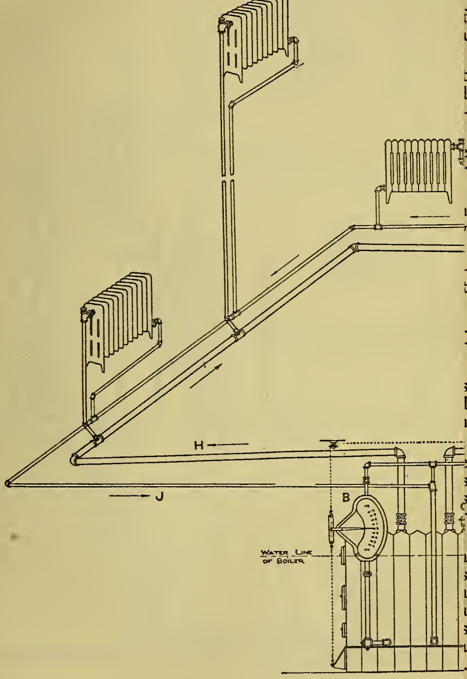
Fig. 8

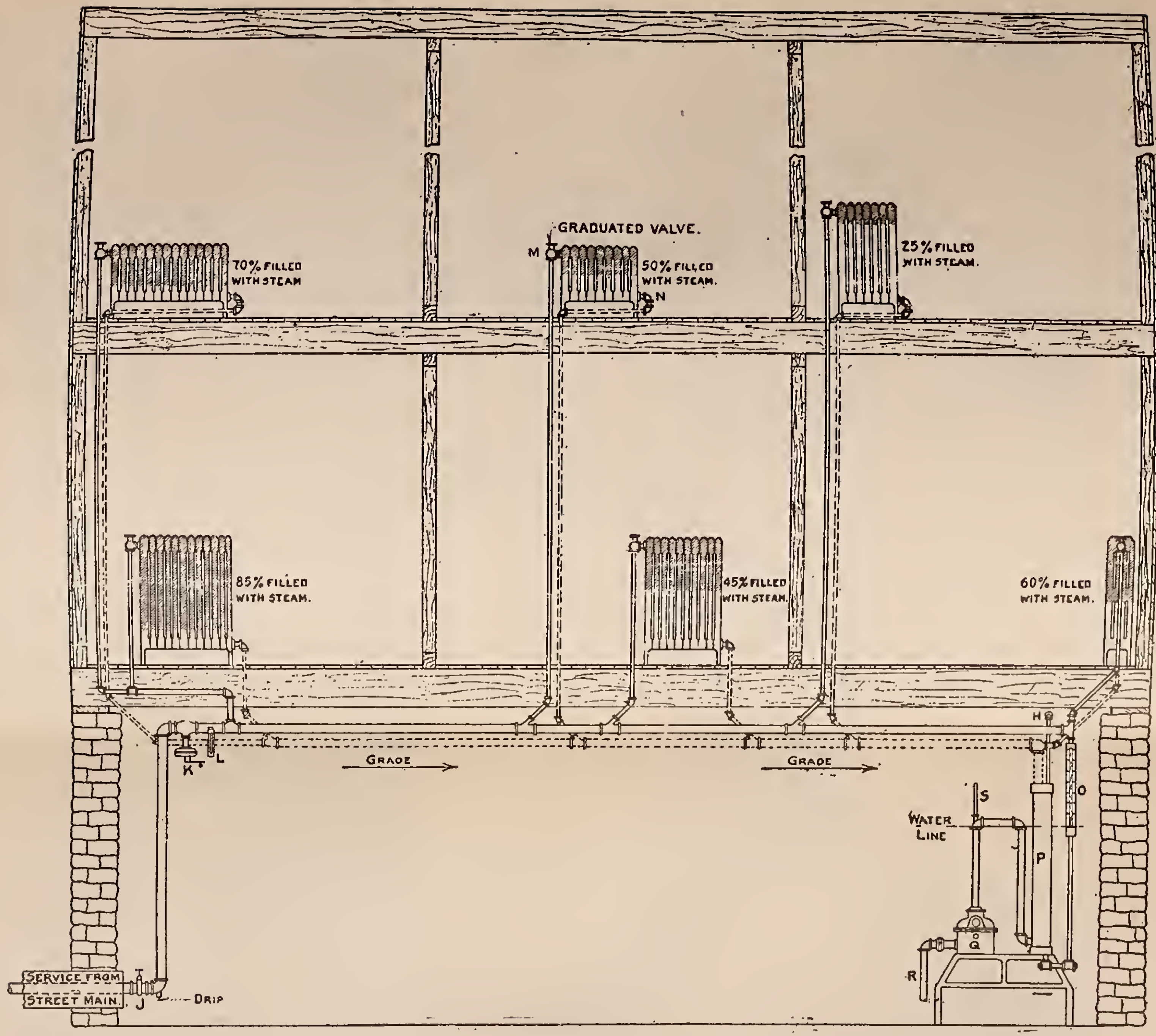
Where steam is used from a boiler in the building, a system of supply and return piping is installed which is similar in many respects to a standard two pipe steam pressure system, as will be observed from the illustration.

The steam main can be drained through a deep water seal into the return or it can be drained by a separate pipe either wet or dry back to boiler. The returns from the radiators are run to boiler where the water separates from the air and falls into the boiler, the air escaping through the vent pipe which is run up in any convenient flue for at least fifteen feet.

The lowest point of the return mains at the boiler should be at least two feet above the water line. *No check valves are used.*

The damper regulator is adjusted to keep the boiler pressure at the desired point.


H
J
B
WATER LINE
OF BOILER



THE ATMOSPHERIC SYSTEM OF STEAM HEATING.
CENTRAL STATION SUPPLY.
"ADSCO" SPECIALTIES.

— SUPPLY MAIN.	N - ORDINARY UNION ELBOW.
- - - RETURN MAIN (UNCOVERED)	O - WATER GAUGE AND DRIP FOR MAIN SUPPLY.
H - AIR LINE TO CHIMNEY OR ATMOSPHERE	P - PIPE RECEIVER.
J - SERVICE GATE VALVE.	Q - CONDENSATION METER.
K - PRESSURE REDUCING VALVE.	R - METER OUTLET TO SEWER
L - MERCURY GAUGE.	S - VENT FOR METER.
M - GRADUATED VALVE.	

NOTE: SHADED PORTION OF RADIATOR SHOWS AIR SPACE DISPLACED BY STEAM AT VARIOUS OPENINGS OF THE GRADUATED VALVE.

EITHER MERCURY OR WATER GAUGE MAY BE INSTALLED AT OWNER'S OPTION.

RADIATION IS OF THE HOT WATER TYPE.

Fig. 7

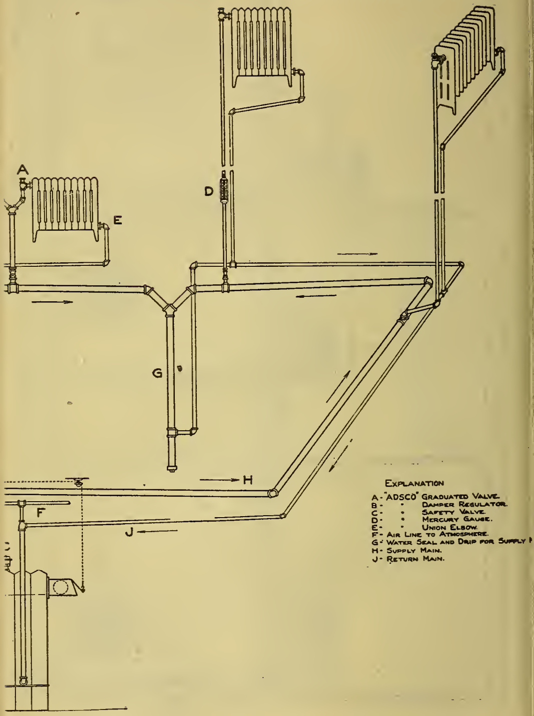

A
D
E
G
H
F
J
Explanation
A - "ADSCO" Graduated Valve.
B - " Damper Regulator.
C - " Safety Valve.
D - " Mercury Gauge.
E - " Union Elbow.
F - Air Line to Atmosphere.
G - Water Seal and Drip for Supply
H - Supply Main.
J - Return Main.

Fig. 8

The Moline System of Vacuum-Vapor Heating.

The Moline System is a heating system that combines in one all of the advantages of vapor vacuum and pressure heating without any of the bad features of such work.

Steam heat is circulated naturally in a system of piping and radiators with as little pressure as in a kettle boiling on the back of a stove.

Any good steam boiler may be used, but it must be selected with proper regard to the work expected of it, the fuel to be used and most of all to the chimney available.

Hot water radiators are used, but the size of the radiators is smaller than is needed for hot water heating.

A two-pipe system of piping is used to carry steam to the tops of the radiators and water and air away from them.

Special radiator supply valves are used with patented restrictor sleeves that give each radiator what steam it needs; no more.

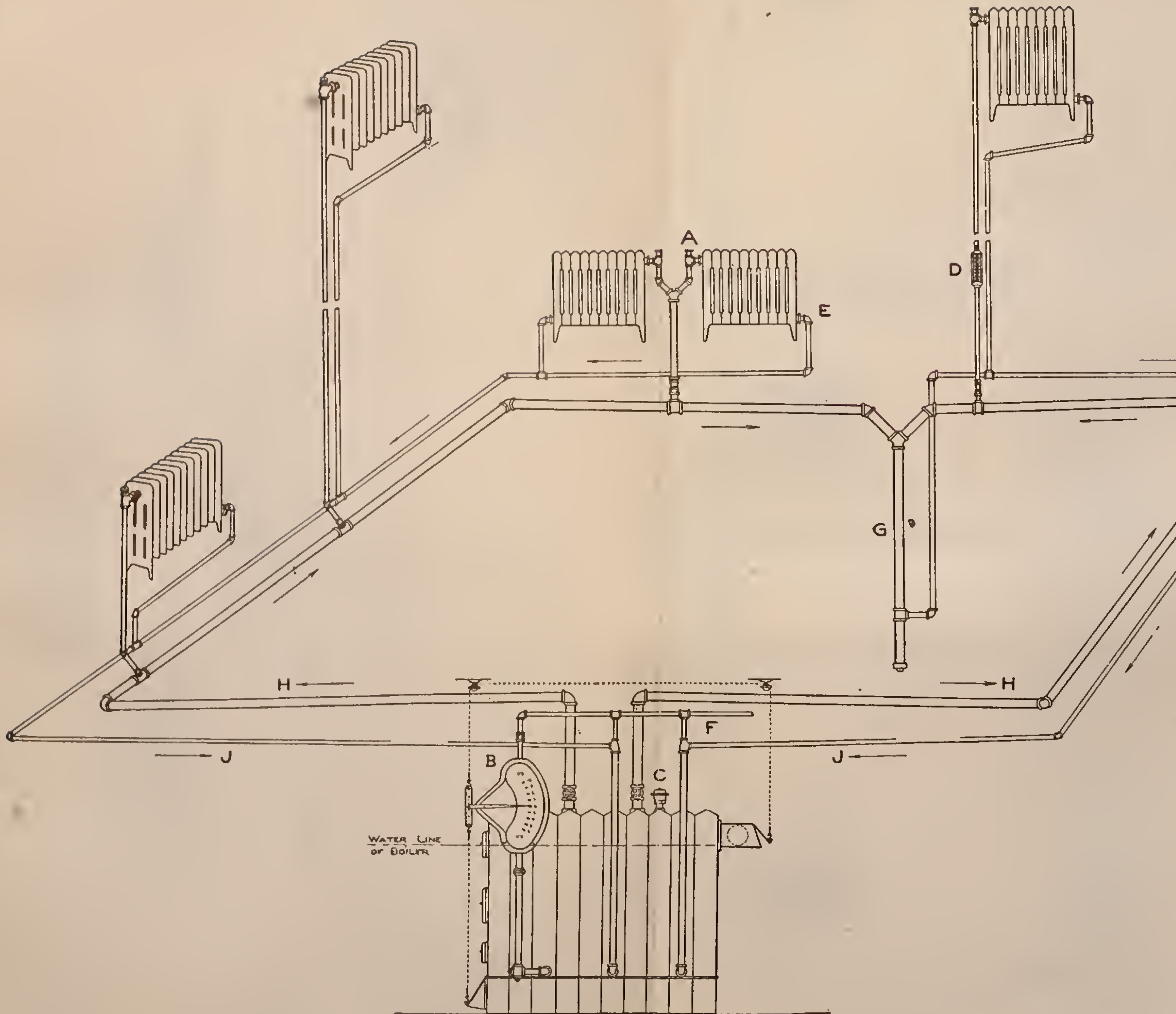
The vent openings on the radiators are plugged. There is no chance for leaks or drips from vents, nor any vents to clog up.

The return valves are simply lock shield valves with patented restrictors in them to pass the air and water, but to limit the amount of steam that can flow into the return lines.

There are no automatic valves of any sort on the radiators. The Moline ejector first relieves the mains of air and then when steam flows through it assists the circulation by dropping the pressure in the air mains through the suction on them.

The Moline condenser condenses the steam from the ejector jet, further assisting circulation, serves as a reservoir for the air when there is a vacuum on the heating system and protects the air trap from steam until all the radiators are hot. It also protects the Moline air trap, the only automatic device on a Moline System, from dirt and other foreign matter.

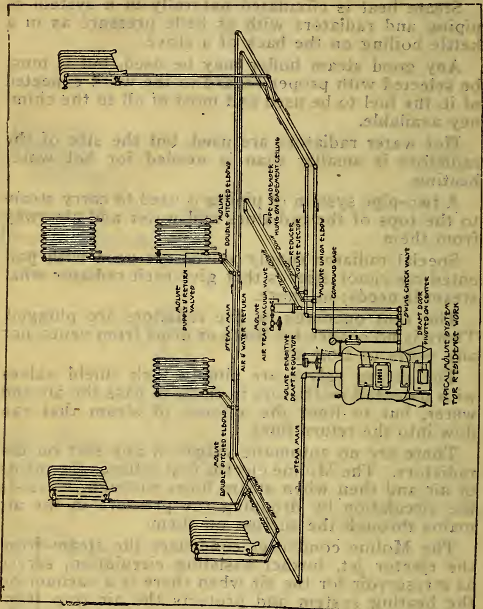
The Moline air trap keeps the piping and radiators open to the atmosphere, giving a free passage of air from the radiators until they are hot.



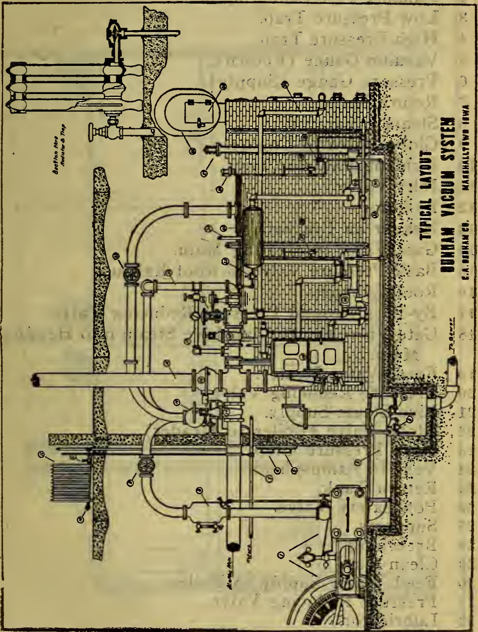
EXPLANATION

A - "ADSCO" GRADUATED VALVE.
B - " DAMPER REGULATOR.
C - " SAFETY VALVE.
D - " MERCURY GAUGE.
E - " UNION ELBOW.
F - AIR LINE TO ATMOSPHERE.
G - WATER SEAL AND DRIP FOR SUPPLY MA
H - SUPPLY MAIN.
J - RETURN MAIN.

Fig. 8

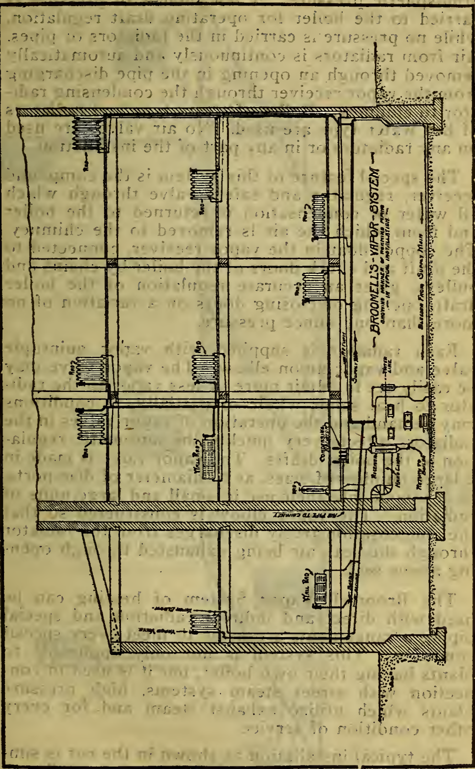


TYPICAL MOLINE SYSTEM FOR RESIDENCE WORK


TYPICAL LAYOUT
DUNHAM VACUUM SYSTEM
C. A. DUNHAM CO.
MARSHALLTOWN IOWA
Section thru Radiator & Trap

Specification Key for Typical Layout of Dunham Vacuum System.

1 Engine and Generator.
2 Exhaust Pipe from Engine.
3 Low Pressure Trap.
4 High Pressure Trap.
5 Vacuum Gauge (Return).
6 Pressure Gauge (Supply).
7 Return Main.
8 Steam Separator.
9 Globe Valve to Engine.
10 Dunham Radiator Trap.
11 Inlet Valve.
12 Radiator.
13 Header on Brackets.
14 Gate Valve to Heating Main.
15 Back Pressure Valve to Roof Exhaust.
16 Roof Exhaust.
17 By-Pass Around Pressure Reducing Valve.
18 Gate Valve Controlling Live Steam into Heating Main.
19 Feed Water Heater.
20 Pressure Reducing Valve.
21 Live Steam Supply.
22 Globe Valve (Boiler to Header).
23 High Pressure Trap.
24 Vent to Atmosphere.
25 Return Tank.
26 Pop Safety Valve.
27 Supports.
28 Breeching.
29 Clean-Out.
30 Feed Water Supply to Boiler.
31 Pressure Reducing Valve.
32 Lubricator.
33 Vacuum Pump.
34 Return.
35 Pump Exhausts.
36 Boiler Feed Pump.
37 Lubricator.
38 Return Tubular Boiler.


BROOMELL'S-VAPOR-SYSTEM

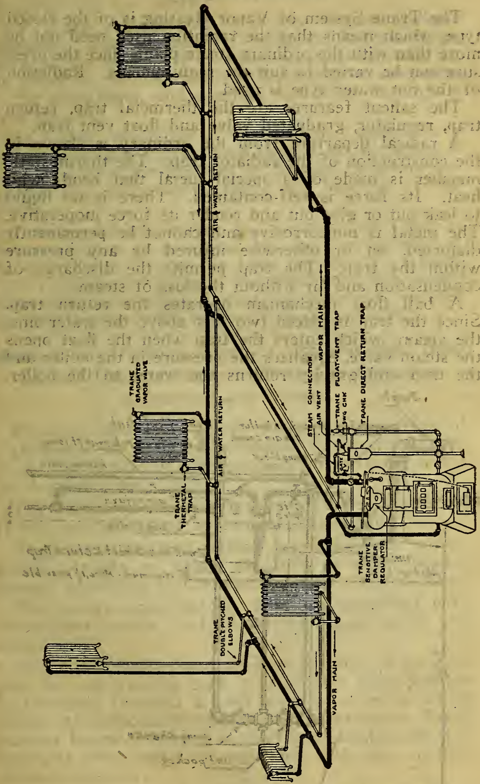
The Broomell Vapor Heating System circulates at atmospheric pressure. A few ounces of pressure is carried to the boiler for operating draft regulation, while no pressure is carried in the radiators or pipes. Air from radiators is continuously and automatically removed through an opening in the pipe discharging from the vapor receiver through the condensing radiator to chimney. Boiler of steam type and radiators of hot water type are used. No air valves are used on any radiators or in any part of the installation.

The special feature of this system is the compound receiver, regulator and safety valve through which all water of condensation is returned to the boiler and from which the air is removed to the chimney. The copper float in the vapor receiver, connected to the draft and check doors of the boiler by chains and pulleys, gives an accurate regulation of the boiler draft, opening or closing doors on a variation of no more than one ounce pressure.

Each radiator is supplied with vapor quintuple valve and vapor union elbow. The vapor valve may be easily set to admit more or less vapor to the radiator to heat same, whole or partially, as conditions may demand and the operation of vapor valves in the radiators affects very quickly the automatic regulation of the boiler drafts. The vapor valve is made in a large number of sizes, as to diameter of disc-ports, to accommodate their use in small and large units of radiation. The vapor elbow is constructed so that the condensation freely discharges from the radiator through the seal, air being exhausted through opening above seal.

The Broomell Vapor System of heating can be used with direct and indirect radiation and special piping arrangements are made to meet every special condition. This system is not only applicable to plants having their own boiler, but it is used in connection with street steam systems, high pressure plants which utilize exhaust steam and for every other condition of service.

The typical installation as shown in the cut is simple. Long supplies being graded from the boiler to low point at farthest end, simplifying control of the radiator by putting valve within easy reach.



Vapor System

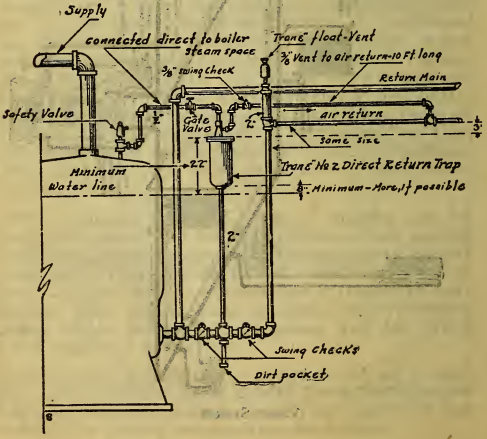
The Trane System.

The Trane System of Vapor Heating is of the closed type, which means that the radiation used need not be more than with the ordinary steam plant, since the pressure can be varied to suit the requirements. Radiation of the hot water type is used.

The salient features are the thermetal trap, return trap, regulator, graduated valve and float vent trap.

A radical departure from the ordinary is shown in the construction of the radiator trap. The thermostatic member is made of a special metal that bends with heat. Its force is self-contained. There is no liquid to leak out or give out and render its force inoperative. The metal is noncorrosive and cannot be permanently distorted, set or otherwise injured by any pressure within the trap. The trap permits the discharge of condensation and air without the loss of steam.

A ball float mechanism operates the return trap. Since the trap is placed two feet above the water line, the steam, which enters the trap when the float opens the steam valve, equalizes the pressure in the boiler and the trap and gravity returns the water to the boiler.



Check valves prevent the water from leaving the boiler or going into the returns.

The drafts are operated by a very sensitive damper regulator. The regulator is connected to the steam space of the boiler. The steam pressure operates on the water in the regulator bottle, which in turn acts on the diaphragm, and controls the drafts through a lever attached.

The valves, which are of the fractional type, have a Jenkins disk and sleeve. One feature of this valve is that the area of the port can be changed by simply removing one screw and change the location of the handle.

A distinguishing feature of the float vent trap is that in addition to providing for the free exhaust of air, it will also prevent air from entering the system. This is accomplished by a flat aluminum disk which seats on a knife edge. A float and thermetal member are used to prevent the escape of steam and water.

Method for Utilizing Heat in Condensation from Central Heating Service, When Condensation is Metered and Wasted.

The accompanying sketch shows an elevation of a graduated valve system of steam heating, designed to utilize the heat in condensation for warming water for domestic use.

The radiators are water type, with feed opening at top, and return at bottom opposite end.

Radiator controlled valves are graduated make, which permits of using as little or much steam needed, according to the requirements of the weather.

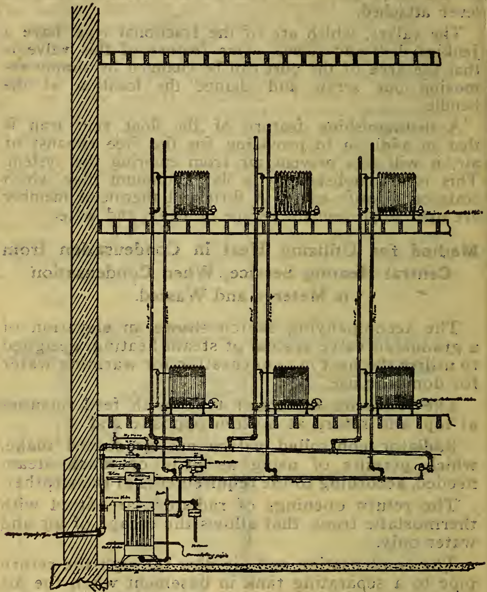
The return openings of radiators are fitted with thermostatic traps, that allows the escape of air and water only.

The condensation and air flow through the return pipe to a separating tank in basement when the air is liberated through a vent pipe fitted with swing check valve, the condensation passes through a closed tubular heater, entering at the top of heater and discharging from outlet through loop with vent, to condensation meter.

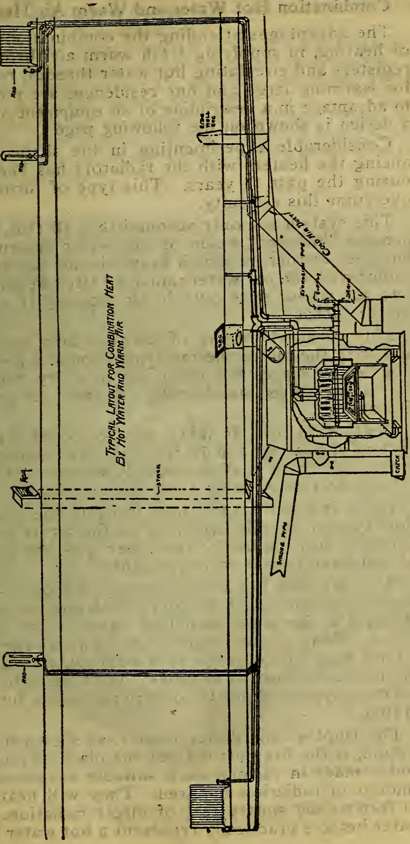
Cold water supply connects near bottom of heater, and discharges through flow near top of tube cham-

ber, and thence passes through an auxiliary heater that raises the water to the required temperature in case the condensation is not sufficient.

The method has proven very efficient, utilizing heat that is frequently wasted, especially when large quantities of warm water are used.



Fed by Central Heating Plant.



Typical Layout for Combination Heat By Hot Water and Warm Air

Combination Hot Water and Warm Air Heating.

The advantages attending the combination system of heating, in supplying fresh warm air through the registers and circulating hot water through radiators for warming large and fine residences are portrayed to advantage in a description of an equipment of which a design is shown on the following page.

Considerable experimenting in the shape of balancing the heaters with the radiators has been done during the past 15 years. This type of furnace has overcome this difficulty.

This system not only accomplishes all that the expensive "indirect" steam or hot water system does, but goes further, in that it keeps the air warm in the rooms with the hot water radiators after we have sent into the rooms pure outside air thoroughly warmed by the furnace.

This constant forcing of pure air into the rooms and with the aid of the radiators produces a circulation which forces the warm air in every corner of the house, thus maintaining an even temperature throughout.

Ventilation, too, is taken care of by this perfect system of heating; the air is constantly changing and moving and as it is all thoroughly warmed before entering the rooms, there is no draft created.

There is a great advantage in using the combination system in mild weather, as the air is warmed from the furnace before the water gets hot and you do not have to run so heavy a fire.

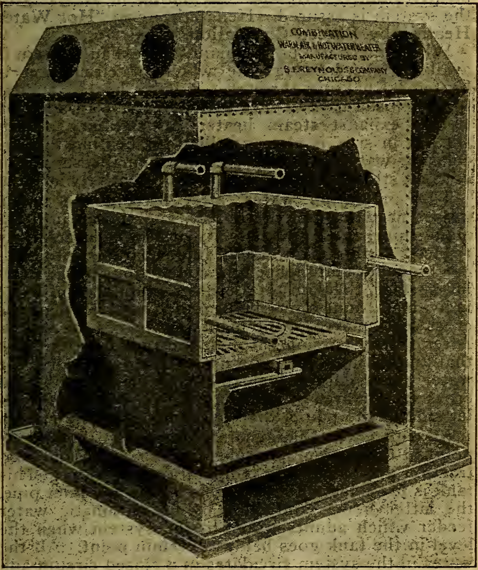
With straight hot water heating, it requires some time to get the water hot and circulating, while with steam it is the same, as it takes quite a fire to raise steam. With all hot water plants it takes the water a long time to cool after it is warmed, which keeps the house overheated at times. We believe by combination system, from 15 to 25 per cent can be saved in fuel.

The Duplex Hot Water Heater, as shown in illustration, is the fire pot; it takes the place of the brick and is made in various sizes, suitable to take care of amount of radiation required. They will heat from 50 feet to 850 square feet of direct radiation. The water heaters practically represent a hot water boiler

in a warm air furnace. One square foot of surface of the hot water heater will heat 50 square feet of direct hot water radiation.

Estimate about one-half of the amount of radiation when warm air is admitted in the same room. The radiator will temper the air, thus increasing the flow of warm air from the registers.

Place radiators in distant and large rooms, especially where a large amount of glass is located, rooms that cannot be reached easily by warm air, also those most exposed.



This is the most reliable furnace for combination heat, by hot water and warm air.

Forced Circulation Hot Water Heating.

In large systems of hot water heating, water is used as the heating medium, and is circulated through a system of supply and return mains, coils or radiators, which, with the exception of certain minor details, are quite similar to those used in steam heating practice. In a properly designed system, the supply and return mains are arranged so that the flow of water will be in the direction naturally induced by gravity, so that this force will assist as far as possible in producing circulation. A pump, usually of the centrifugal type, is placed in the circuit, by means of which positive and controllable circulation in all parts of the system is assured. Hence the term **"Hot Water Heating by Forced Circulation."**

Where there is a power plant, and exhaust steam is available for heating, the water of circulation is heated by passing through a tubular heater, similar to the closed type of feed water heater. In addition to the exhaust steam heater, an auxiliary heater, smaller in size, is also installed, for heating the circulating water with live steam, when the supply of exhaust steam is either insufficient or entirely lacking.

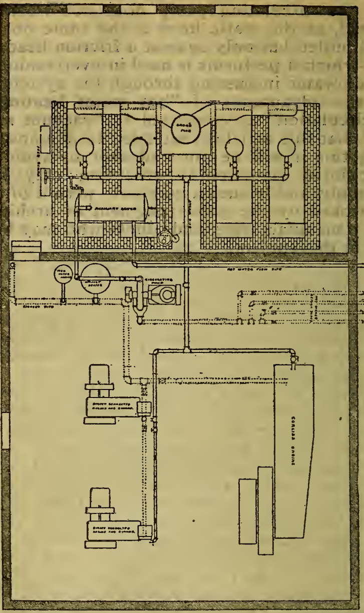
The circulating water, after leaving the pump, passes first through the heater, and thence into the main supply line. The velocity of flow is successively reduced as this main supply line separates into various branches and thence into connections to the heating surface, the sum total cross section area of these individual connections being much greater than the cross section area of the main as it leaves the heater. After slowly passing through the radiation units, so that ample time for giving up its heat is afforded, the water again gathers velocity through reduced total cross section area of mains until it passes into the inlet side of the pump, thereby completing the circuit.

An expansion tank, generally located at the highest point of the system, provides for expansion and contraction due to varying temperatures of water. This tank is provided with an overflow pipe and inlet pipe, the latter being controlled by an automatic water feeder which admits water to the system when the level in the tank goes below a certain point. All the water in the system circulates in a closed circuit, and the same water is used over and over again, no fresh water being admitted except to equalize the loss from

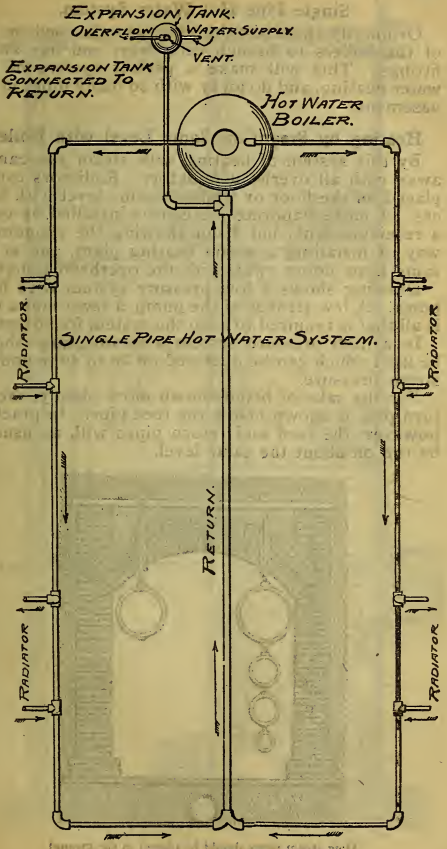
leakage and overflow from expansion tank. Consequently, the circulating pump does not work any **static head,** as the static head is the same on both inlet and outlet, but only against a **friction head,** and all work which it performs is used in overcoming the friction of water in passing through the system.

It is the advantages of **"hot water heating by forced circulation"** as compared to **"vacuum steam heating"** that this article is intended to demonstrate. In doing this it will be our endeavor to avoid any highly colored statements, presenting only facts, stated simply, and in such a way as to permit of their being checked by the good judgment of architects, engineers, manufacturers, and others who may be interested in this subject.

POWER PLANT SHOWING EVANS EXHAUST-HOT WATER HEATING SYSTEM.



Typical Layout for Force Circulation of Hot Water Heating.


EXPANSION TANK.
OVERFLOW
WATER SUPPLY.
VENT.
EXPANSION TANK CONNECTED TO RETURN.
HOT WATER BOILER.
SINGLE PIPE HOT WATER SYSTEM.
RADIATOR
RADIATOR
RADIATOR
RADIATOR
RETURN.

Single Pipe Hot Water System.

Ordinarily there should be a twin ell, used on top of the boilers to branch each way, and use sweep fittings. This will make a perfect system of hot water heating, and do away with so many pipes in the basement.

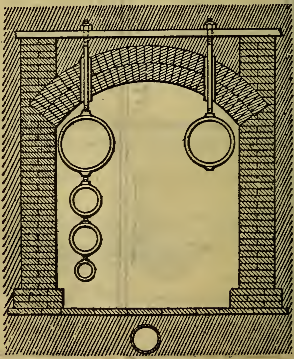
Heating by Steam on Same Level with Boiler.

By this system of heating with steam you can do away with all overhead radiators. Radiators can be placed on the floor or walls on same level with boilers. A more elaborate job can be installed by using a receiving tank, but I am showing the economical way of installing a steam heating plant, and at the same time, doing away with the overhead radiation.

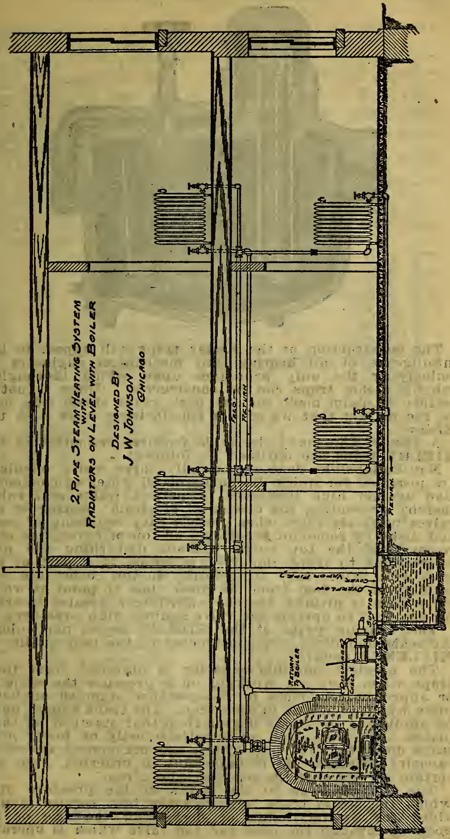
Drawing shows a low pressure system with hand pump. A few strokes of the pump, a few times a day, is all that is required to keep the system free of water.

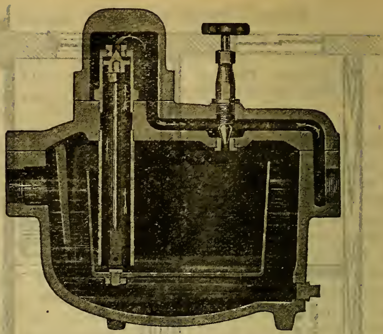
In a high pressure system a steam pump should be used which can be operated on 20 to 40 pounds of steam pressure.

For the sake of being shown more plainly, the return pipe is shown below the feed pipe. In practice, however, the feed and return pipes will, as usually, be run on about the same level.



How steam pipes should be placed in the ground


2 Pipe Steam Heating System
with
Radiators on Level with Boiler
Designed By
J W Johnson
Chicago
Flow
Return
Return
Vapor Pipe
Cover
Overflow
Tank
Suction
Return to Boiler
Discharge
Check V



The construction of the Kieley traps will appeal to the intelligence of all heating and mechanical engineers as embodying the only principles upon which thoroughly reliable steam traps can be constructed. There is not a feature or claim made for any high grade steam trap now on the market that we cannot convincingly meet with the Kieley.

A few of the many desirable features embodied in the KIELEY traps are outlined as follows:

Non-Collapsible floats; unusually large valve openings are provided for quick discharge of all water of condensation against high pressures; a perfect water seal valve, thereby preventing the discharge of steam; seating of the valves perfectly tight when closed; easy repairing of seats and disks by removing small cap on top of cover; the easy removal of the top cover without disturbing the pipe connections to trap; the by-pass which is a part of the trap with valve; easy accessibility in top cover; the suspending of the float from the cover close to point at which valve-stem is pivoted, thereby affording a greater leverage for the float to operate the valve against high pressures.

The wearing parts of the KIELEY traps, particularly the seats and disks, are constructed of the best quality of KIELENEY metal.

The greatest possible capacity is obtained from these traps when they are working on a pressure the same as or approximately close to the pressure stamped on brass plate which is affixed to each trap. The traps should never be applied to pressures higher than that stamped on these plates. The traps will work satisfactorily on lower pressures down to 1 lb., but with a proportionately decreased capacity; therefore it is important in ordering traps for certain service that the pressures be given.

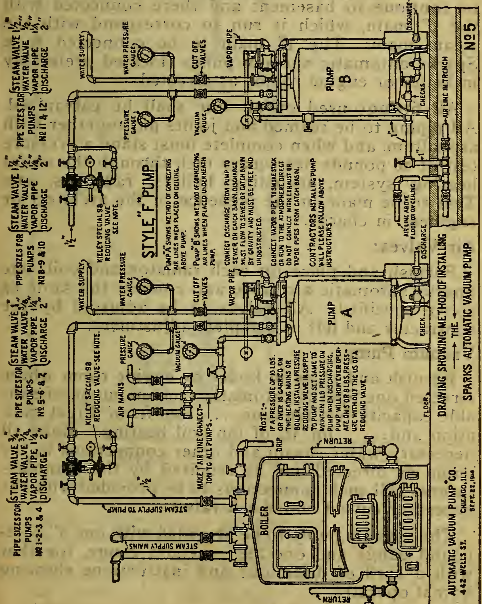
The difference as to the limits of the pressure upon which the steam traps will give the best service is provided for by increasing or decreasing the size of the opening through the disk and the valve which is operated by the float.

The higher the pressure the smaller the valve; the lower the pressure the larger the valve.

NUMBER	0	1	2	3	4	5	6
Size pipe connections, inches	½	¾	1	1¼	1½	2	2½
Capacity in pounds of water per hour	450	750	1,700	2,700	3,800	6,600	7,500
Capacity in square ft. of radiation	1,300	3,200	3,500	7,000	10,000	16,000	20,000
Capacity lineal feet 1-inch pipe	4,000	6,000	10,000	15,000	25,000	40,000	50,000

The above ratings are based upon favorable conditions and operation of steam traps.

Order traps large enough, and it is ESPECIALLY IMPORTANT that you give the range of steam pressures you wish traps to operate under.



How to Specify the Sparks System of Heating.

In addition to the supply and return pipes, etc., used in connection with the Heating System, furnish and install the necessary air piping for equipping the entire plan with the Sparks System of Positive Steam Circulation, supplying all the necessary air valves, vacuum pump, etc., complete as hereinafter specified.

From the automatic air valves on all radiators and coils run ¼″ connections and tie into ⅜″ horizontal arms, which are run and connected to ½″ risers, run to correspond with the steam risers. The ½″ risers to continue to basement and there connected with the 1″ main, which is run to correspond with the steam main. The 1″ main to be connected to a Sparks automatic vacuum pump (located preferably in boiler or engine room) as directed.

All fittings used on air line shall be galvanized. All piping to be reamed and joints put together with asphaltum, and when complete must stand a pressure test of 40 pounds per square inch through the entire heating system, including boilers, radiators, etc. Test to be made in the presence of the architect or engineer in charge.

Air Valves:

Furnish and place on each radiator and coil, one Sparks automatic air valve and connect the same as above specified. All valves to be adjusted by the contractor and left in complete adjustment.

Vacuum Pump:

Furnish and place in boiler or engine room where directed one Sparks automatic vacuum pump, of suitable capacity for handling......sq. ft. of direct radiation and......lin. ft. of fan coil heating. Make all necessary water, steam and other connections to the pump as directed and as required by the manufacturers. All such connections to be provided with the necessary cut-off and check valves.

The vacuum pump to be provided with one 5″ compound gauge and one 3½″ vacuum gauge, together with a card of directions and instructions showing how it operates.

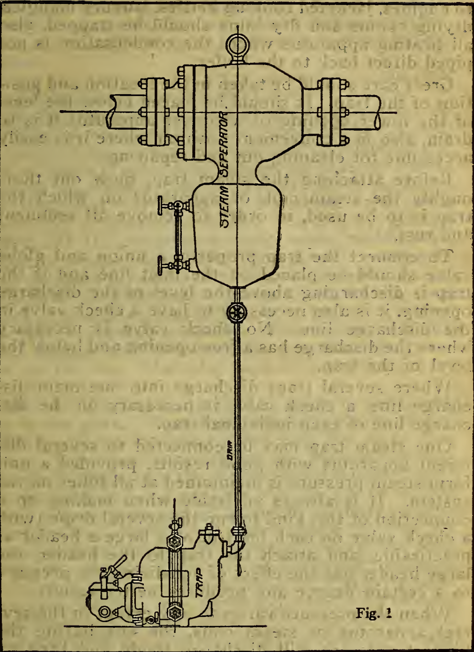


Fig. 1

Steam Traps and Their Duties.

Steam traps are a necessary factor in nearly all power and heating plants, as they effect a great saving by automatically ejecting the condensation without loss of steam, as rapidly as it is accumulated.

All main steam lines should have a trap located at the farthest point from the boiler, thereby insuring dry steam and the highest efficiency for engines, pumps or whatever work the steam has to perform.

All steam separators on main steam lines leading to engines, jacketed cooking kettles, laundry mangles, drying rooms and dry kilns should be trapped, also all heating apparatus where the condensation is not piped direct back to the boiler.

Great care should be taken in the location and position of the trap. It should be placed below the level of the lower opening of whatever apparatus it is to drain, also in a convenient position where it is easily accessible for cleaning out and repairing.

Before attaching the steam trap, blow out thoroughly the steam coil, or apparatus on which the trap is to be used, in order to remove all sediment and rust.

To connect the trap properly, a union and globe valve should be placed on the inlet line and if the trap is discharging above the level of the discharge opening, it is also necessary to have a check valve in the discharge line. No check valve is necessary where the discharge has a free opening and below the level of the trap.

Where several traps discharge into one main discharge line, a check valve is necessary on the discharge line of each individual trap.

One steam trap may be connected to several different apparatus with good results, provided a uniform steam pressure is maintained at all times on the system. It is always advisable when making up a connection of this kind to run the several drips (with a check valve on each line) into as large a header as practicable, and attach the trap to the header, the large header has the effect of equalizing the pressure to a certain degree and produces better results.

When the pressure varies to any extent in the several apparatus or steam coils, the one having the highest pressure will discharge freely and back up into those having a lower pressure, in cases of this kind the best results can only be obtained by attaching separate traps to the ones having unequal pressure.

A very common trouble with steam traps is caused by low places or pockets in the piping system. Water accumulates in these low spots and is forced through into the trap at intervals, causing an uneven discharge. Where the quantity of accumulated water is

sufficient and the steam valve in the line is opened suddenly, this water is forced through the pipes at such a high velocity as to cause water hammer, which is very destructive to the whole piping system. Always avoid all low spots or pockets in your piping system.

Fig. (1) shows an Anderson steam trap connected to a horizontal steam separator.

The Anderson is an ideal steam trap, perfect in every detail, accurately built of materials best suited for the purpose. Every part absolutely interchangeable. Complete with water gauge, by-pass, air valve, blow-off valve and sediment strainer. Both the valve and valve seat can be removed without breaking a steam joint or pipe connection. The valve is always locked with at least three inches of water, making the escape of steam impossible. The strainer and sediment chamber prevent sediment or scale getting into the valve. A glass water gauge fitted to the trap makes it possible to ascertain at a glance whether the trap is working properly. These traps will lift water against any back pressure less than the pressure at the trap. Made for high or low pressure or exhaust steam.

Fig. (2) illustrates a means of utilizing the latent heat in the water of condensation from steam heated radiation, where the water is not used for other purposes. This illustration shows an Anderson steam trap which discharges the condensation into an auxiliary heating coil. This coil can be placed either above, below or on a level with the discharge opening of the trap; however, if placed above the trap the steam pressure must be sufficient to elevate the condensation. By this arrangement the latent heat that is stored in the water can be utilized, thereby effecting a great saving. The Anderson trap, being of constant flow, will force the water through these extra hot water coils in a continuous stream and not create water hammer. In installations of this kind a globe valve, check valve and union should be placed between the radiation and steam trap as well as between the coil and trap.

It is obvious that installations of this nature will insure a considerable saving.

Anderson Trap

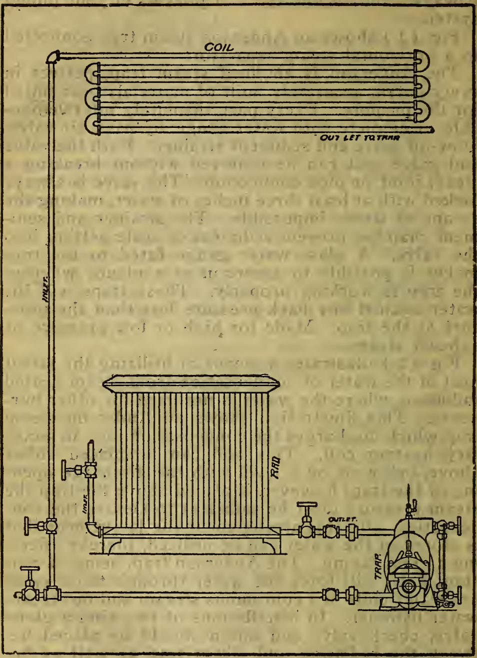
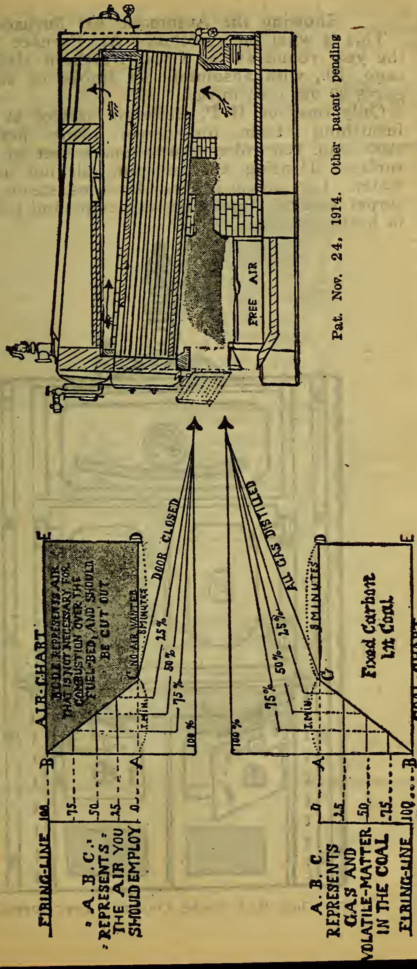


Fig. 2

Automatic Air Furnace, Chicago, Ill.

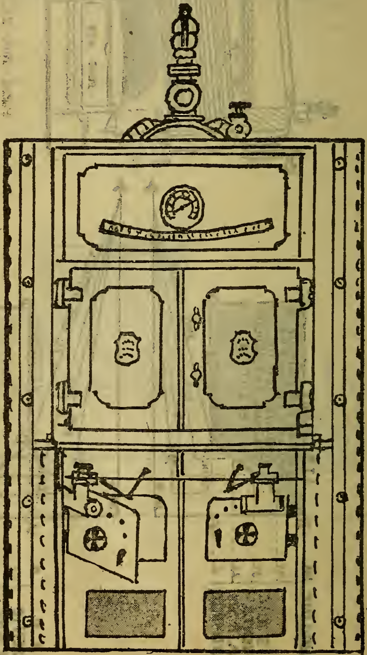


Pat. Nov. 24, 1914. Other patent pending

Showing the Automatic Air Furnace

This is what the Automatic Air Furnace is doing the year round at the Great Northern Hotel, Chicago, Ill., with absolutely no smoke or soot, and saves 30 per cent in fuel.

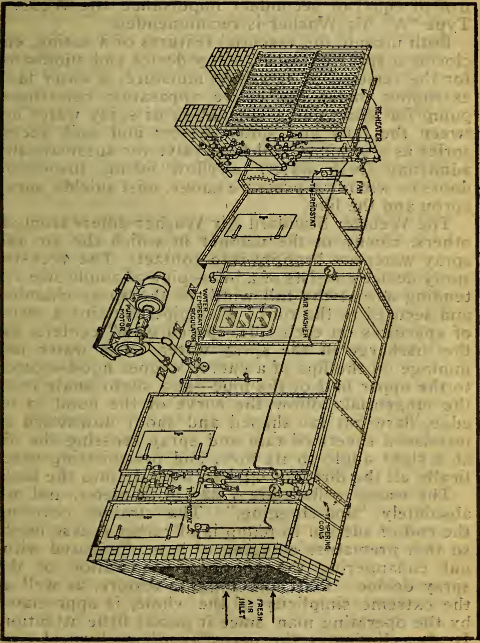
Only one 300 H. P. Boiler in service at a time, furnishing steam for power plant, peak load 1200 amp. 230 volts, 45,000 square feet of heating surface. Heating and pumping all hot and cold water. Live steam for four kitchens, steam vacuum carpet system, Duplex steam pumps and live steam in heating system.



The Only Real Smoke Consumer Ever Invented

Soot and smoke is the bane of most every city. With this furnace installed these obnoxious nuisances will be eliminated and the blessings of a clean city may be enjoyed by all.

This furnace completely consumes all smoke and soot and should be installed in every power plant in America.



The Webster Standard Air Washer and the Webster Type "A" Air Washer will be discussed here, since they are the types most frequently used in ordinary heating and ventilation. Where either air cleansing or humidity control is the dominant factor in the selection of the apparatus, the Webster Standard Air Washer is recommended. Where air cooling is of importance and air cleansing and humidity control of equal or secondary importance, the Webster Type "A" Air Washer is recommended.

Both include the essential features of a casing, enclosing a spray chamber, spray device and eliminator for the removal of entrained moisture; a water tank extending under the entire apparatus; centrifugal pump for maintaining circulation of spray water between the tank and spray device; and such accessories as a strainer, ball float valve for automatically admitting fresh water, overflow fitting, inspection doors or windows, pressure gauge, mist shields, spray apron and the like.

The Webster Standard Air Washer differs from all others, chiefly in the manner in which the air and spray water are brought into contact. The Webster spray device consists of a brass pipe of ample size extending across the full width of the spray chamber and secured to the roof. This pipe contains a series of apertures on each side, spaced on 6" centers, for the discharge of the spray water. The water jets impinge on the lips of a curved copper hood-secured to the upper half of the pipe—at a slight angle from the tangential, follow the curve of the hood to its edge, flare out fan-shaped and shoot downward in interlaced sheets of rain and spray crossing the air at a right angle to its flow, and precipitating practically all the dirt from the air directly into the tank.

The water orifices are 7/32" in diameter, and are absolutely "non-clogging." The strainer covering the end of suction to pump is of rather coarse mesh, so that premature clogging of it is eliminated without endangering the continuous operation of the spray device. This non-clogging feature, as well as the extreme simplicity of the whole, is appreciated by the operating man, since it means little attention. It also eliminates the necessity of mechanical contrivances for automatically flushing the spray device to keep it clean—all of which have been more or less impractical in actual service.

The Webster Eliminator is characteristic and secures many advantages over other types of eliminators. It is built up of horizontal V-shaped, lipped baffles arranged in two separate rows, staggered vertically. The vertical distance between baffles is 4½", which reduces the resistance to the air to a minimum consistent with perfect removal of entrained moisture. Being slightly inclined from the horizontal, the baffles allow the water and any dirt which may have escaped the spray, to drain immediately to a vertical gutter, thence to the tank below. By this arrangement each baffle is handling an equal amount of moisture, and same is immediately removed from further contact with the air current, thereby insuring perfect elimination of entrained moisture.

Mist shields secured to the side angle at the front of the casing break up eddy currents and together with the apron at the front of the tank prevent mist from falling outside.

The length of the Webster Standard Air Washer (3'-10") adapts it to the limited space usually available for apparatus of this character.

The Webster "Type A" Air Washer in its general construction is the same as the Webster Standard. The length is increased to 7'-0", and the method of bringing the water and air into contact is different.

The essential factors necessary to secure highly efficient cooling, are: extremely intimate contact between air and water without handling an excessive water volume; comparatively long contact, and uniform distribution of air and water over the entire spray chamber area. The mist nozzles are placed about one foot from the front of the casing, a header extends the entire width of the apparatus, a few inches above the water line in the tank. Risers are tapped into this at intervals for supplying the mist nozzles, and extend the full height of the casing. The spacing of the risers and nozzles is dependent on the amount of cooling that is desired.

The Webster spiral mist nozzles (patented) used in the Webster "Type A" Air Washer are made of brass. Each consists of a base which screws into the riser, and a casing enclosing a spiral interior casting for giving the water a rotative effect. The casing with enclosed spiral screws into the base. The interior has two spiral water passages of uniformly de-

creasing cross sectional area. The jets from each spiral leave the same tangentially; the centrifugal action in addition to the interference of the two jets in the orifice causes the water to be atomized into a cone-shaped cloud of mist and fog. The "cones" from the adjacent nozzles interlace so that a uniform distribution of water is secured.

The mist nozzles afford the means of breaking up the spray water so finely that the aggregate surface of the particles into which each gallon of water is divided is very large, thus increasing the rapidity of heat transfer from air to water with the attendant cooling.

Elaborate tests were necessary to determine the cooling obtainable by the "Type A" air washer for different initial air conditions, water temperatures and water volumes. The large number of variables involved makes a rational formula for the calculation of cooling under all conditions practically impossible; with the experimental data resulting from the above mentioned tests, the calculation upon which to proportion air and water volumes for obtaining any desired result, is a very simple matter.

For air cleansing this type is not excelled by any apparatus of the mist nozzle type.

The Webster System of Humidity Control can be applied to either type of apparatus with equal facility. It involves simply the use of ordinary thermostatic devices with which all operating engineers are familiar. The system provides for controlling and maintaining the desired absolute humidity of the air leaving the air washer, and which reheated to the desired room temperature, maintains closely the predetermined relative humidity.

For this purpose a constant predetermined temperature of the air leaving the air washer is maintained by controlling the steam supply to the tempering coil.

The spray water in the air washer tank is warmed and maintained at a practically constant predetermined temperature by the use of a water temperature regulator which controls steam injection through steam and water mixers placed inside the air washer tank. In other words, the desired absolute humidity is obtained by maintaining a practically constant predetermined differential between the temperature of

the air leaving the air washer and the temperature of the spray water used.

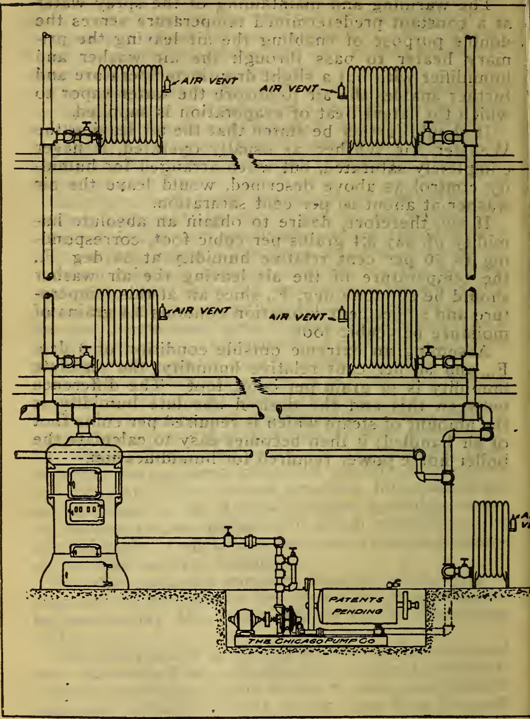
The warming and maintaining of the spray water at a constant predetermined temperature serves the double purpose of enabling the air leaving the primary heater to pass through the air washer and humidifier with but a slight drop in temperature and further enables the air to absorb the water vapor to which the latent heat of evaporation is supplied.

It should further be stated that the air leaving the Webster Air Washer, as usually operated, is never completely saturated, but when arranged for humidity control as above described, would leave the air washer at about 90 per cent saturation.

If we, therefore, desire to obtain an absolute humidity of, say 3.4 grains per cubic foot, corresponding to 50 per cent relative humidity at 65 deg. F., the temperature of the air leaving the air washer should be about 48 deg. F., since air at this temperature and 90 per cent saturation contains 3.4 grains of moisture per cubic foot.

Assuming an extreme outside condition of 0 deg. F., and 50 per cent relative humidity, the absolute humidity is ¼ grain per cubic foot. The difference between this and the desired absolute humidity is the amount of steam which is required per cubic foot of air handled; it then becomes easy to calculate the boiler horse power required for humidification.

Condensation Pumps



Cut illustrating the "Chicago" Condensation Pump and how it can be applied in keeping a heating system clear of condensation water. This condensation pump is far superior over any other make.

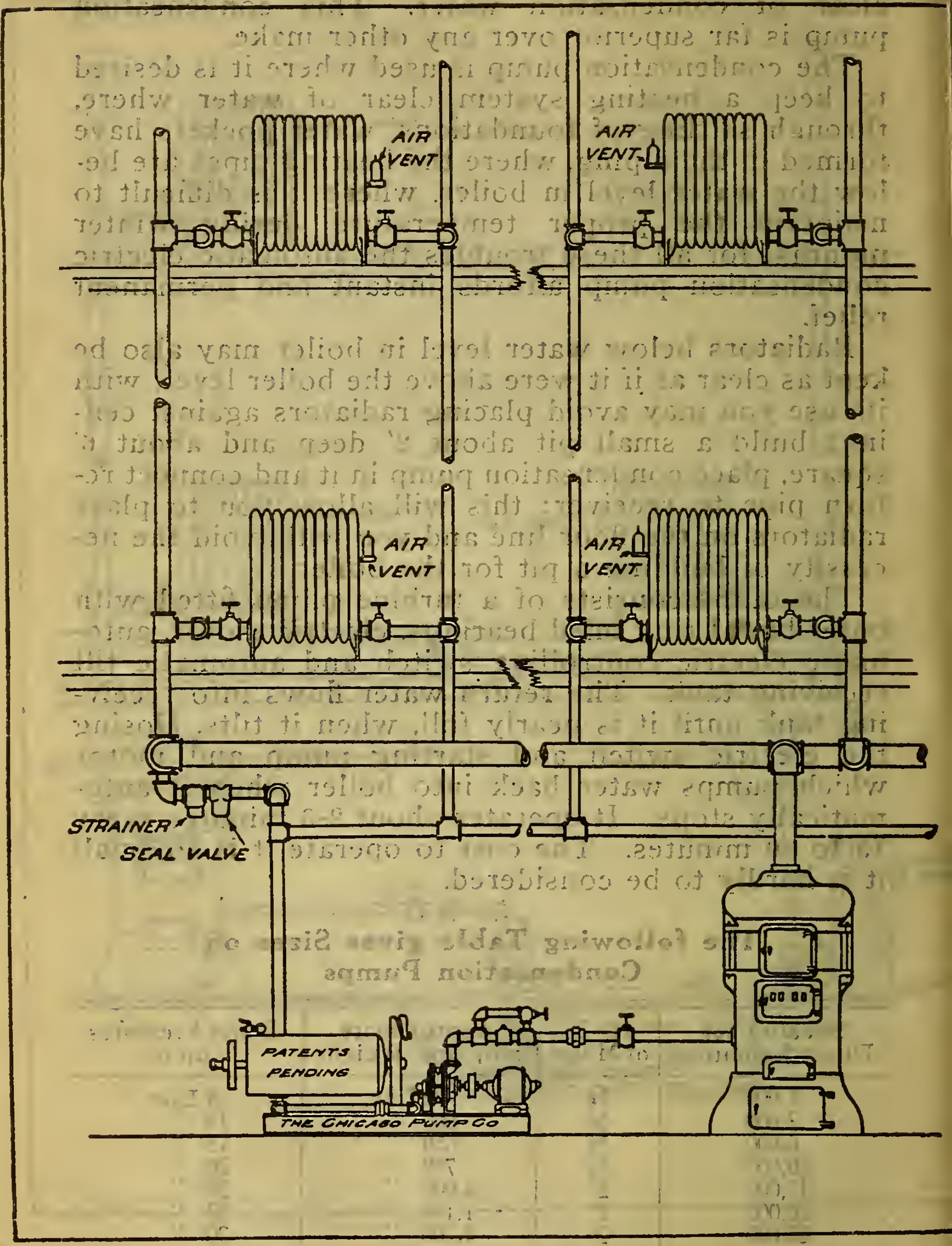
The condensation pump is used where it is desired to keep a heating system clear of water where, through settling of foundations, water pockets have formed in the piping, where the heating pipes are below the water level in boiler, where it is difficult to maintain the proper temperature during winter months; for all these troubles the automatic electric condensation pump affords instant and permanent relief.

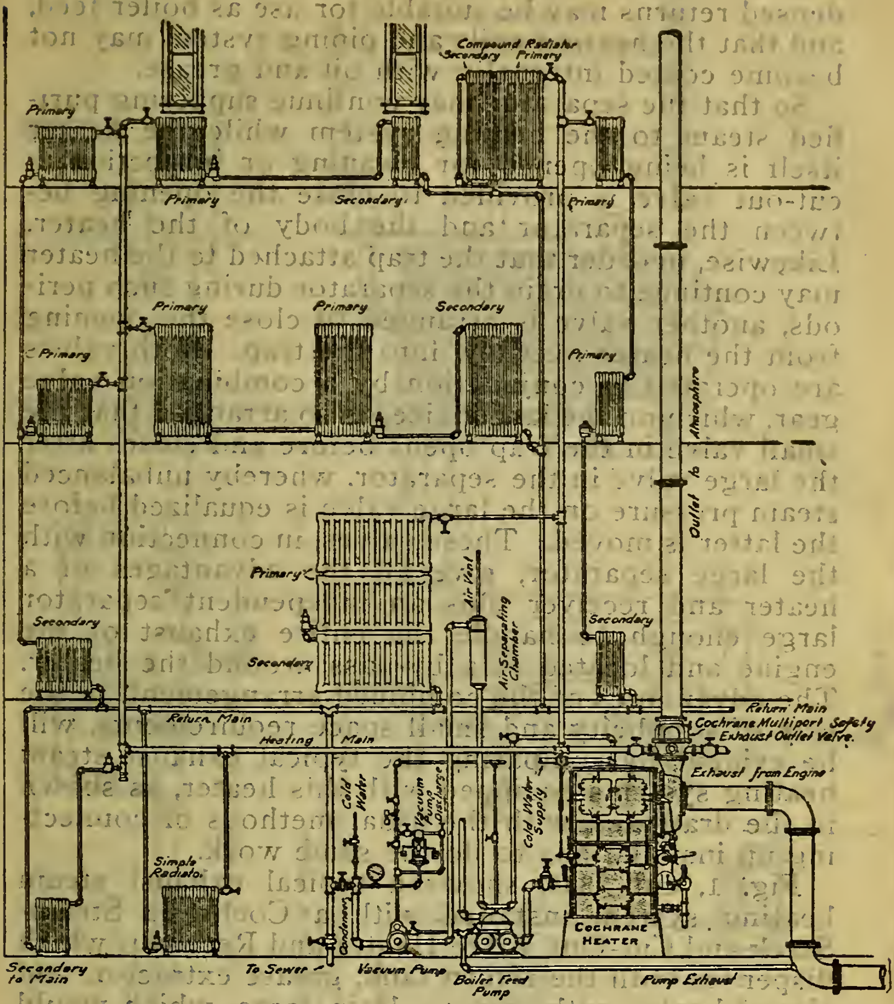
Radiators below water level in boiler may also be kept as clear as if it were above the boiler level; with its use you may avoid placing radiators against ceiling; build a small pit about 2′ deep and about 6′ square, place condensation pump in it and connect return pipe to receiver; this will allow you to place radiators on the floor line and you will avoid the necessity of building a pit for the boiler.

The outfit consists of a turbine pump fitted with outer board ring oiled bearings, electric motor, automatic electric controlling switch and automatic tilt receiving tank. The return water flows into receiving tank until it is nearly full, when it tilts, closing the electric switch and starting pump and motor which pumps water back into boiler when it automatically stops. It operates about 2-3 minutes every 15 to 30 minutes. The cost to operate it is so small it is hardly to be considered.

The following Table gives Sizes on Condensation Pumps

Square Feet Direct Radiation	H. P. of Motor	Approximate Shipping Weight	Boiler Pressures up to
1.000	1/8	300 Lbs.	8 Lbs.
3.000	1/2	600 "	15 "
6.000	1/2	650 "	15 "
10.000	3/4	700 "	20 "
15.000	2	1.000 "	20 "
20.000	2	1.100 "	20 "
25.000	2	1,200 "	20 "


AIR VENT
AIR VENT
AIR VENT
AIR VENT
STRAINER
SEAL VALVE
PATENTS PENDING
THE CHICAGO PUMP CO

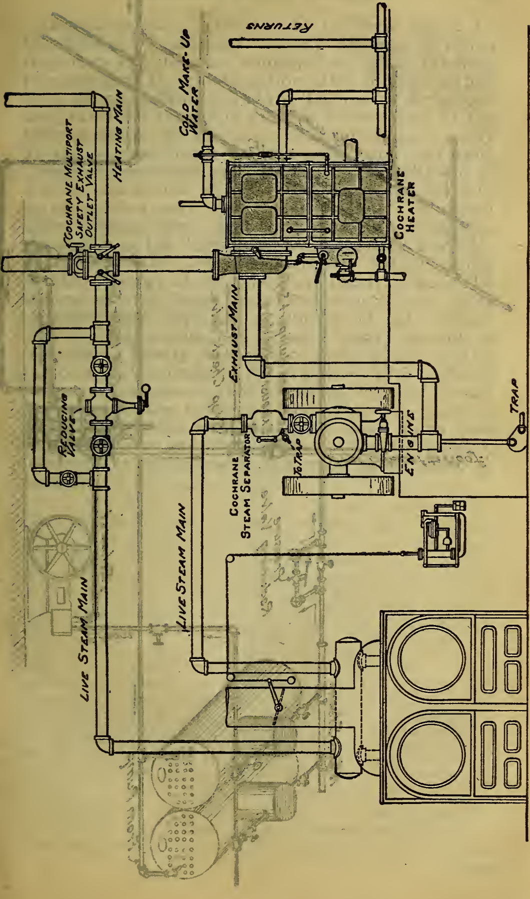


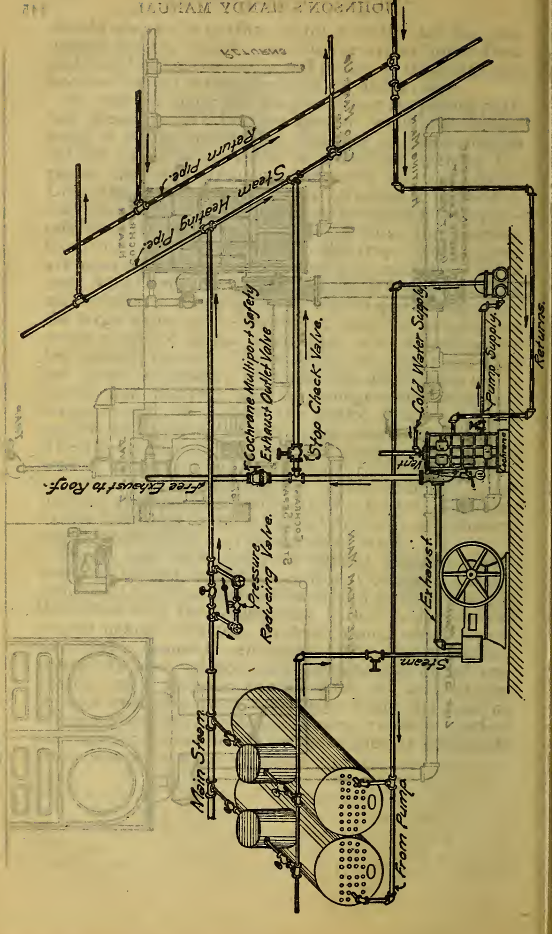
The Cochrane Improved Steam-Stack and Cut-Out Valve Heater and Receiver is an open feed water heater for use in connection with exhaust steam heating systems of both the back pressure and vacuum types, and is distinguished by the extra large oil separator forming a part of it. This separator has sufficient capacity to purify all of the exhaust steam delivered by the engines and pumps, that is, not only the steam consumed in heating the boiler-feed water and reheating the returns in the heater, but also the surplus exhaust steam which passes to the heating or drying system or escapes to the atmosphere. Steam that is to be used in a heating system

should always be purified of oil in order that the condensed returns may be suitable for use as boiler feed, and that the heating coils and piping system may not become coated internally with oil and grease.

So that the separator may continue supplying purified steam to the heating system while the heater itself is being opened for cleaning or inspection, a cut-out valve is provided to close the opening between the separator and the body of the heater. Likewise, in order that the trap attached to the heater may continue to drain the separator during such periods, another valve is arranged to close the opening from the heater overflow into the trap. Both valves are operated in conjunction by a combination valve gear, which on the larger sizes is so arranged that the small valve in the trap opens before and closes after the large valve in the separator, whereby unbalanced steam pressure on the large valve is equalized before the latter is moved. These valves, in connection with the large separator, give all the advantages of a heater and receiver plus an independent separator large enough to handle the entire exhaust of the engine and located in a by-pass around the heater. The advantages of the combined arrangement, in the way of simplicity and small space requirements, will be evident by comparing the typical exhaust steam heating systems equipped with this heater, as shown in the drawings, with the usual methods of connecting up installations to do the same work.

Fig. 1, cut 2836, shows a typical exhaust steam heating system installed with a Cochrane Steam-Stack and Cut-Out Valve Heater and Receiver, which dispenses with the return tank, grease extractor, and closed heater with trap to drain same, which would have been required otherwise. The closed heaters ordinarily used, without the protection of an oil separator, soon become coated with oil and grease, greatly reducing their efficiency, while the heating efficiency of the Cochrane heater remains perfect indefinitely, since the heat transmission is immediate from steam to water.


Returns
Cold Make-Up Water
Heating Main
Cochrane Multiport Safety Exhaust Outlet Valve
Cochrane Heater
Exhaust Main
Reducing Valve
Trap
Engine
To Trap
Cochrane Steam Separator
Live Steam Main
Live Steam Main
Boilers


Return Pipe.
Steam Heating Pipe.
Cochrane Multiport Safety Exhaust Outlet Valve
Stop Check Valve.
Cold Water Supply.
Pump Supply.
Returns.
Vent
Cochrane
Free Exhaust to Roof.
Pressure Reducing Valve.
Exhaust.
Steam.
Main Steam.
From Pump.

Illustrates the application of the new heater to the Simonds Compound Vacuum System, in which secondary radiators are employed to utilize the heat remaining in the condensation after it has escaped from the main steam radiators. The use of the secondary radiators results in a lower temperature of the returns which can therefore be handled more easily by the vacuum pump without cold water injection.

Similar economies are shown in the installation of a steam-stack and cut-out valve heater and receiver in connection with the Kieley System. A dozen other exhaust steam heating systems in general use are shown in the "Exhaust Steam Heating Encyclopedia," published by the Harrison Safety Boiler Works, from which we take these illustrations. The money savings from the elimination of the extra separator and trap, and a number of gate valves, elbows, tees, piping and other fittings, amount to from $50 to $500 in each case, or about 25 per cent of the cost of the heater. As compared with a closed heater arrangement, this improved type of heater performs all the functions, and takes the place of closed heater, hot well, expansion tank, boiler feed water skimmer and filter, make-up water regulator, independent oil separator and trap, valves and connections.

Heat Regulating Systems.

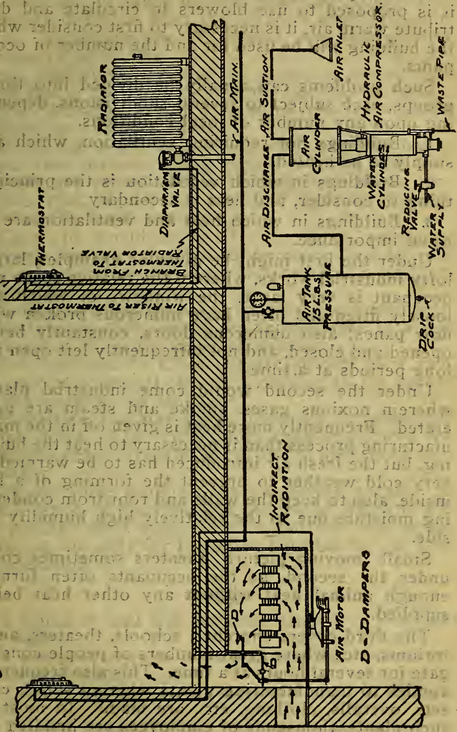
Automatic heat regulation is now frequently applied to systems of heating and ventilating, especially in offices of the better class. Its advantages are well known, producing, as it does, the most economical consumption of steam and the highest degree of comfort.

Where the system consists of thermostats connected to valves controlling the heat sources by means of compressed air a diaphragm valve is placed on the radiators.

These valves are furnished by the heat regulating contractor in the commercial sizes and shapes; globe, angle, corner, offset, with and without unions, and have very closely the same dimensions in the body, length of tailpiece, as the commercial valves of all makes, and are provided with standard threads. The system consists of an air compressor which may be of any type, and operated by water, steam or electricity, as may be desired. They are made in different sizes to conform to the different size plants. The air compressor delivers air to the storage tank. From this tank the air is piped to the thermostats located in various parts of the building, as desired. From each one of these thermostats another pipe is run to the valve or to the dampers to be controlled.

Various sizes and methods of running pipe are employed depending on the kind and character of the building. The piping to the thermostats is called the main pipe, and the pipe from the thermostat to the valves or dampers is called the branch pipe. The main piping is run somewhat similar to steam piping in starting it with large sized pipe, and reducing to smaller size as each thermostat is reached, and, of course, the size of pipe is dependent upon the number of thermostats used in the building. The branch piping is usually small size pipe, seldom more than ⅛" galvanized iron pipe. All pipe used in temperature regulating systems is galvanized iron, with galvanized iron fittings. The piping is entirely concealed in the walls and beneath the floors, excepting where it is run in a regular pipe shaft, and the short connection from the floor to the radiator valves, as illustrated in the sketch.

Space does not permit, at this time, to explain the various piping systems in use, but piping of this kind must be run straight and be absolutely without leakage.



JOHNSON SYSTEM OF TEMPERATURE REGULATION.

Blower System and Its Operations

When a problem of heating is presented, wherein it is proposed to use blowers to circulate and distribute warm air, it is necessary to first consider what the building will be used for and the number of occupants.

Such problems can usually be divided into three groups, each subject to several subdivisions, depending upon any number of local conditions.

1. Buildings not requiring ventilation, which are simply to be heated.

2. Buildings in which ventilation is the principal thing to consider, and heat is secondary.

3. Buildings in which heat and ventilation are of equal importance.

Under the first might be given as examples, large, lofty industrial works, wherein the relative space per occupant is very large, the windows of which are loosely fitted and often have numerous broken window panes; also numerous doors, constantly being opened and closed, and not infrequently left open for long periods at a time.

Under the second would come industrial plants wherein noxious gases, smoke and steam are generated. Frequently more heat is given off in the manufacturing process than is necessary to heat the building, but the fresh air introduced has to be warmed in very cold weather to prevent the forming of a fog inside, also to keep the walls and roof from condensing moisture due to the relatively high humidity inside.

Small "moving picture" theaters sometimes come under the second, as the occupants often furnish enough animal heat without any other heat being supplied.

The third covers churches, schools, theaters, auditoriums, etc., where great numbers of people congregate for several hours at a time. This also frequently applies to manufacturing plants wherein shoes, corsets, overalls, clothing, etc., are made. In most of such plants, thousands of employees are huddled together in rooms of limited area and height, thus presenting a condition requiring the most careful engineering to keep the air up to even the poorest standards, without creating objectionable drafts.

The next thing to consider is the prevailing atmospheric conditions outside and what the building will be used for, in order to determine the proper temperature inside to meet the severest weather conditions. Buildings can be divided into two general groups to cover this:

(a) Buildings in which the occupants are at complete rest or the occupation is more or less sedentary.

(b) Buildings in which the work requires constant activity or laborious effort.

Under (a) would be listed all kinds of public buildings, also manufacturing plants wherein the employees are seated simply feeding material to machines that require no muscular exercise beyond moving the hands and arms.

Class (b) would cover all other types, excepting perhaps, factories devoted to the production by special process of something which requires a uniform temperature at all times.

Buildings under Class (a) should be provided with a heating plant to maintain a temperature of about 70 degrees F., in the severest weather.

For buildings in Class (b) are subject to a subdivision into several classes, according to the nature of the work, as for instance:

Foundries, machine shops, furniture factories and paint shops. The temperature usually allowed for these are respectively 50, 60, 70 and 80 degrees in zero weather.

By carefully studying the conditions peculiar to the location of the plant and the use to which it will be put, the most economical proportions can be arrived at, not only for first cost, but also for the cost of operation.

Fuel.

1 pound of coal will evaporate from 7 to 10 pounds of water.

1 pound of dry pine wood will evaporate from 4 to 5 pounds of water.

1 ton of anthracite coal requires a space of 42 cubic feet.

1 ton of bituminous coal requires a space of 44 cubic feet.

1 ton of coke requires a space of 80 cubic feet.

150.35 cubic feet of air are required for the combustion of 1 pound of coal.

The following table shows the resulting inside temperatures when the outside temperature varies from zero with a plant designed for zero weather:

RESULTING INSIDE TEMPERATURE

Class of Buildings	Below Zero Outside				Above Zero Outside		
	Temp. Desired Inside, at zero outside	Temp. Inside, at 10° below outside	Temp. Inside, at 20° below outside	Temp. Inside, at 30° below outside	Temp. Inside, at 10° above zero outside	Temp. Inside, at 20° above zero outside	Temp. Inside, at 30° above zero outside
Foundries	50°	41°	32°	22°	57°	63°	70°
Machine Shops	60°	52°	43°	34°	67°	73°	78°
Furniture Factory	70°	63°	55°	45°	76°	81°	86°
Paint Shops	80°	74°	67°	59°	85°	89°	92°

Outside Temperature	Days per Year	Hours at 10 Hrs. per day	Hours at 24 per day
Zero and Below	4	40	96
Zero to 10 above	6	60	144
10 to 20	11	110	264
20 to 30	34	340	816
30 to 40	61	610	1464
40 to 50	47	470	1128
50 to 60	53	530	1272
Totals	216	2160	5184

The days of prevailing temperatures throughout the year is often a question of importance, to approximate the cost of operation. For latitudes lying between 38 and 46 degrees north, the following table represents a fair average:

The next in order is to determine the heat losses due to the outside exposure, as represented by the glass, wall, floor and roof surfaces of the building. The following table gives the losses in B. T. U.'s per square foot of exposed surface for one degree rise per hour.

Thus for 70° rise for 1000 sq. ft. each, of 12" brick wall, single windows, wood floor on the ground, composition roof over wood and four doors of 60 sq. ft. each, would require heat as follows:

1000 x 70° x 0.33 = 2310 B. T. U. for wall.
1000 x 70° x 1.20 = 8400 B. T. U. for windows.
1000 x 70° x .10 = 700 B. T.U. for floor.
1000 x 70° x .30 = 2100 B. T. U. for roof.
240 x 70° x .42 = 101 B. T. U. for doors.
13611 B. T. U. total.

To this must be added the following:
10% for northerly exposure.
10% if heated in day time only.
30% if heated in day time only and greatly exposed.
50% if heated only at long intervals.

Allowances must also be made for broken windows, open doors to the outside or apartments not heated, etc., which usually is taken care of by an extra air air allowance varying from 10 per cent to 25 per cent, according to the judgment of whoever is laying it out.

A concrete example will best illustrate the further procedure, in the determination of the heat required, the volume of air, etc. For this purpose we will assume that the exposure requires 1,918,400 B. T. U.; that the building contains 1,080,000 cu. ft. of space; that it is to be heated to 65 degrees in zero weather, in the day time only:

Heat for exposure ....1,918,400 B. T. U.
Add 10% for heating in day time
only .... 191,840 B. T. U.
2,110,240 B. T. U.

To care for leakages through windows, doors, etc., an additional amount of heat equal to an air change every two hours will be allowed, raised from 30 degrees to 65 degrees. Thus 1,080,000 cu. ft. ÷ 2 hrs. = 540,000 cu. ft. per hr. × (65°-30°) × .0807 (wt. of 1 cu. ft. air at 30°) × 0.2375 (specific heat of air) = 361,000 B. T. U.

Adding this to the exposure loss as found above, makes a total of 2,471,240 B. T. U. per hour.

It is customary to raise the temperature of the air at the heater to about 130°. In a building of this size the average loss of heat from the ducts by radiation will be roughly 20°, which taken from 130 will leave 110° as the average temperature of the air entering the building. As the temperature to be maintained inside is 65°, then 110° — 65° = 45°, the temperature lost to outside exposure.

Therefore, 45° X 0.2375 = 10.7 B. T. U. per pound of air; then 2,471,240 B. T. U. ÷ 10.7 = 231,000 pounds of air per hour, or 3850 pounds per minute.

As the air heated by the coils has to be raised from 0° to 130°, then the total heat to be supplied will be as follows:

130° X 0.2375 X 231,000 lbs. = 7,150,000 B. T. U., or nearly three times the heat represented by the exposure.

If, however, the air is to be recirculated, then the apparatus will only have to be as large as the difference between the lowest allowable inside temperature and the maximum temperature from the heater, which we will say is 32° inside to 130° at the heater. Therefore, the heat required will be 98 X 0.2375 X 231,000 lbs. = 5,375,000 B. T. U., cr about 25 per cent less heat.

The volume of air required will be as follows, for 3850 lbs. air per minute:

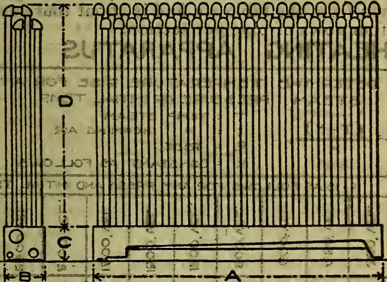
Temp. of air	Cu. ft. air in 1 lb.	Cu. ft. of air per minute
0°	11.58	44,500
32°	12.38	47,600
65°	13.14	50,600
110°	14.35	55,200
130°	14.85	57,200

The velocity of the air over the heating surface should be somewhere between 600 and 1800 ft. per minute. Between 900 and 1200 feet represents average practice. At 1000 ft. velocity, the free area

through the heater would have to be somewhere near 50 square feet. Referring to the following table, under No. 40 sections, with pipes 9'-9" and 10' high, we find a free area of 49.8 sq. ft. and 567.8 sq. ft. of heating surface per section.

THE "A B C" HEATER

DIMENSIONS OF SECTIONS



No. of Section	A	B	C	D	No. of Section	A	B	C	D	No. of Section	A	B	C	D
12	3'-11⅛"	8¾"	6¾"	3'-7⅛"	22	5'-2⅝"	8¼"	7⅛"	5'-4½"	31	7'-3⅜"	8¾"	7⅞"	8'-4½"
12A	3-11½	8¾	6⅝	3-4½	22A	5-2¾	8¼	7⅛	4-10½	31A	7-3⅜	8¾	7⅞	7-7½
12B	3-11⅝	8¾	6⅝	2-10½	22B	5-2⅝	8¼	7⅛	4-4½	31B	7-3⅜	8¾	7⅞	6-10½
15	3-7⅜	8¾	6⅝	4-1½	25	5-10⅝	8¼	7⅛	5-10½	36	8-5⅜	8¾	7⅞	9-4½
15A	3-7⅜	8¾	6⅝	3-10½	25A	5-10⅝	8¼	7⅛	5-4½	36A	8-5⅜	8¾	7⅞	8-4½
15B	3-7⅜	8¾	6⅝	3-7½	25B	5-10⅝	8¼	7⅛	4-10½	36B	8-5⅜	8¾	7⅞	7-4½
18	4-3⅜	8¾	6⅝	4-10½	28	6-7⅛	8¼	7⅛	6-7½	40	9-4⅝	8¾	8¾	11-1½
18A	4-3⅜	8¾	6⅝	4-4½	28A	6-7⅛	8¼	7⅛	6-1½	40A	9-4⅝	8¾	8¾	10-1½
18B	4-3⅜	8¾	6⅝	3-10½	28B	6-7⅛	8¼	7⅛	5-7½	40B	9-4⅝	8¾	8¾	9-1½

The average volume through the heater when recirculating will be 47,600 × 57,200 = 52,400 ÷ 49.8 sq. ft. = 1050′ velocity per minute.

By means of the following table, the temperature rise for any number of four row sections in depth can be determined for any velocity.

Thus we want 130° with entering air at 32°, or a rise of 98°. If the steam pressure is 5 pounds, with a temperature of 227° and the entering air 32°, the difference is 195°; dividing this by 98° equals 1.99, which is the proper factor for 1050′ velocity, which by interpolation from the table we find is about four sections with four rows of pipe per section.

HEATING APPARATUS

TO DETERMINE TEMPERATURE RISE FOR ANY STEAM PRESSURE OR INITIAL TEMP

$$R = \frac{(T-t)}{K},$$

T = TEMP. STEAM
t = " INCOMING AIR
R = RISE
K = CONSTANT AS FOLLOWS

K IS AS FOLLOWS FOR ANY PRESS AND INITIAL TEMP.

Nº OF SECTIONS DEEP	300′ VEL.	450′ VEL.	600′ VEL.	900′ VEL.	1200′ VEL.	1500′ VEL.	1800′ VEL.	2100′ VEL.	2400′ VEL.	3000′ VEL.
1	3.9	4.46	4.91	5.57	6.2	6.66	7.09	7.45	7.80	8.4
2	2.19	2.5	2.76	3.13	3.48	3.75	3.97	4.19	4.38	4.71
3	1.615	1.85	2.04	2.30	2.56	2.75	2.92	3.08	3.22	3.48
4	1.333	1.525	1.68	1.91	2.12	2.28	2.42	2.55	2.67	2.87
5	1.21	1.35	1.46	1.66	1.85	1.99	2.11	2.22	2.32	2.50
6	1.142	1.23	1.32	1.49	1.66	1.785	1.895	2.00	2.085	2.26
7	1.11	1.065	1.24	1.385	1.54	1.66	1.76	1.85	1.94	2.08
8	1.088	1.130	1.19	1.310	1.44	1.55	1.65	1.73	1.81	1.95
9	1.072	1.113	1.152	1.26	1.36	1.46	1.55	1.635	1.71	1.85
10	1.06	1.10	1.130	1.220	1.305	1.40	1.49	1.57	1.64	1.766

DIVIDE (T-t) BY ABOVE CONSTANT = TEMPERATURE RISE FOR ANY STEAM PRESSURE AND ANY INITIAL TEMP. IF "t" IS ABOVE ZERO ADD TO "R" FOR FINAL TEMPERATURE IF "t" IS BELOW ZERO DEDUCT FROM "R" FOR FINAL TEMPERATURE

As each of the sections has 567.8 sq. ft. of heating surface, so the entire heater will have 2271.2 sq. ft., or about 6600 lineal feet of one-inch pipe.

The amount of steam required can be determined as follows:

Total heat in steam at 5 lbs. is..........1156 B. T. U.
Heat in condensation at 212 deg.......... 180 B. T. U.
Latent heat given off is.................. 976 B. T. U.

5,375,000 ÷ 976 = 5500 lbs. of steam per hour maximum.

As there are 33,305 B. T. U. per boiler H. P. then dividing same by 976 = 34.1 lbs. water per H. P.; then 5500 ÷ 34.1 = 161 H. P. capacity.

If coal contains 13,000 B. T. U. per lb. and boiler evaporates at 70 per cent efficiency, then from each pound of coal 9100 B. T. U. goes to evaporation, which divided by 976 gives 9 1/3 lbs. of steam per pound of coal.

34.1 ÷ 9.33 = 3.45 lbs. of coal per H. P. hour × 161 H. P. = 556 lbs. of coal per hour.

This would amount to about 300 tons per year for period of average heating, at 10 hours per day.

If there is enough exhaust steam to supply the required amount, then no fuel will have to be burned for heating.

The steam main can be determined in several ways. From a steam table find the volume at 5 lbs. pressure, which is 20.08 cu. ft. per lb. × 5500 lbs. = 110,440 cu. ft. per hour or 1840 cu. ft. per minute.

6000 ft. velocity is a reasonable figure to allow, hence $\frac{1840 \times 144}{6000} = 44.2$ sq. in. area, or 7½ in. diameter of main. If the main is very long, then to prevent loss of pressure, it had better be made 8 inches diameter, but if short, 7 inches will be ample.

The return main is usually 6/10 of the area of the steam main which would make it necessary to use a 6″ return for the condensation. With a vacuum system attached, slightly smaller returns can be used. Some even advocate one size smaller steam mains when a vacuum system is attached, but this practice is questionable, as it takes just so much power to move a given volume of steam, whether it is done by pressure or vacuum.

The next thing is the selection of a fan suitable for the work.

It is desirable to keep the air pressure as low as possible, so as not to waste power in driving the fan. The heater will require from 0.25 inches to 0.50 inches in most cases, depending upon the number of sections deep and the velocity. In this case it will be about 0.3 inches.

The distributing ducts should be so designed as not to exceed 0.75 inch loss of pressure. This will make about one inch static pressure, which represents approximately 2/3 of the total pressure, making the total pressure about 1.5 inches or 0.87 ounces.

As we want about 51,000 C. F. M. at 70 degs. temp., then a 160" fan will be required at 242 R. P. M., requiring about 40 H. P. to drive.

A No. 13 Sirocco fan at 170 R. P. M. will also do the work, requiring 22.05 H. P. The speeds and powers in both of above cases are found as follows:

The volume is directly proportional to the speed, and the power is directly proportional to the cube of the speed; hence if the volume desired is between two sizes or two pressures, in the table the required speed and power can be determined by proportion.

The pressure will be as the square of the speed.

Having now determined the size of the apparatus, the method of distributing the air to properly heat and ventilate the building must be considered.

"A B C" STEEL PLATE FANS

Speeds, Capacities and Horse-Powers at Varying Pressures

Fan No.	Dia m Wheel	Static Press.	½"	1"	1½"	2"	2½	3"	3½"	4"
50	30	C.F.M.	3840	5425	6640	7650	8595	9400	10110	10810
		R.P.M.	471	665	816	945	1060	1150	1250	1330
		B.H.P.	.88	2.48	4.55	7.00	9.81	12.85	16.20	19.75
60	36	C.F.M.	5475	7740	9460	10900	12250	13400	14410	15420
		R.P.M.	393	555	681	786	880	961	1040	1110
		B.H.P.	1.25	3.53	6.49	9.94	14.00	18.35	23.10	28.10
70	42	C.F.M.	7100	10020	12280	14150	15900	17400	18700	20010
		R.P.M.	336	475	583	675	755	825	890	950
		B.H.P.	1.62	4.58	8.35	12.93	18.19	23.80	29.90	36.60
80	48	C.F.M.	8640	12200	14950	17200	19350	21150	22800	24350
		R.P.M.	294	416	511	590	660	722	780	832
		B.H.P.	1.97	5.57	10.20	15.71	22.10	28.90	36.50	44.50
90	54	C.F.M.	11000	15540	19000	21900	24600	26950	29000	31000
		R.P.M.	262	370	454	525	587	641	693	740
		B.H.P.	2.52	7.08	13.00	20.00	28.10	36.85	46.40	56.50
100	60	C.F.M.	14050	19850	24300	28000	31450	34400	37000	39600
		R.P.M.	236	333	409	473	529	578	625	665
		B.H.P.	3.21	9.05	16.65	25.60	35.95	47.10	59.10	72.30
110	66	C.F.M.	16600	23500	28800	33100	37200	40700	43800	46900
		R.P.M.	214	303	371	430	480	525	568	605
		B.H.P.	3.80	10.75	19.70	30.25	42.50	55.60	70.00	85.60
120	72	C.F.M.	20300	28700	35100	40500	45500	49700	53500	57300
		R.P.M.	196	278	340	394	440	481	520	555
		B.H.P.	4.64	13.10	24.00	37.00	52.00	68.00	85.50	104.50
140	84	C.F.M.	27400	38700	47400	54500	61300	67000	72200	77250
		R.P.M.	168	238	292	337	378	413	445	475
		B.H.P.	6.25	17.75	32.40	49.80	70.00	91.70	115.20	140.9
160	96	C.F.M.	34500	48900	59800	68900	77300	84500	91000	97500
		R.P.M.	147	208	256	296	331	362	390	416
		B.H.P.	7.88	22.30	41.00	62.90	88.40	115.5	145.4	178.0
180	108	C.F.M.	42600	60300	73800	85000	95500	104300	112500	120000
		R.P.M.	131	185	227	262	293	320	346	369
		B.H.P.	9.75	27.55	50.50	77.60	109.0	143.0	180.0	219.0
200	120	C.F.M.	51600	73000	89400	103000	115700	126500	136100	145800
		R.P.M.	118	166	204	236	264	289	312	332
		B.H.P.	11.8	33.30	61.20	93.50	132.1	173.0	217.50	266.0
220	132	C.F.M.	61400	86800	106000	122200	137400	150200	162000	173000
		R.P.M.	107	151	185	214	240	262	283	302
		B.H.P.	14.0	39.60	72.50	111.50	157.0	206.0	259.0	316.0
240	144	C.F.M.	72000	101800	124500	143500	161000	176000	189500	203000
		R.P.M.	98	139	170	197	220	241	260	377
		B.H.P.	16.5	46.50	85.00	131.00	184.0	241.0	303.0	370.5

NOTE—Any of the above fans, when running at the speed and pressure indicated, will deliver the volume of air and require no more power than given in the table

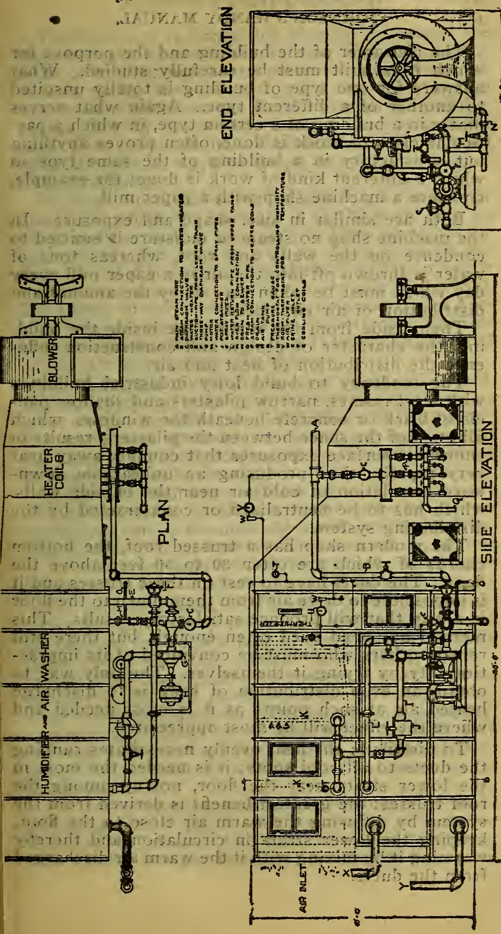
Allowances must be made for the inefficiency of the motive power and for transmission losses between motive power and the fan.

Fans and Blowers

Speeds, Capacities and Horse Powers of Single Inlet, Standard Width Fans at Various Pressures

Figures Given Represent Dynamic Pressures in Ounces per Square Inch. For Static Pressure Deduct 28.8%. For Velocity Pressure Deduct 71.2%.

No. of Fan	Diameter of Wheel		¼ Oz.	½ Oz.	¾ Oz.	1 Oz.	1¼ Oz.	1½ Oz.	1¾ Oz.	2 Oz.	2½ Oz.	3 Oz.
00	3	CU. FT.	38	56	67	77	87	95	102	110	122	135
		R. P. M.	2290	3230	3960	4580	5120	5600	6050	6460	7232	7920
		B. H. P.	.006	.013	.024	.037	.051	.068	.085	.105	.145	.190
0	4½	CU. FT.	87	125	152	175	197	215	232	250	277	305
		R. P. M.	1524	2152	2640	3048	3400	3732	4040	4304	4816	5280
		B. H. P.	.011	.030	.053	.084	.116	.153	.193	.228	.30	.423
1	6	CU. FT.	165	220	270	310	350	380	410	440	490	540
		R. P. M.	1145	1615	1980	2290	2560	2800	3025	3230	3616	3960
		B. H. P.	.0185	.052	.095	.147	.205	.270	.34	.42	.58	.76
1¼	7½	CU. FT.	242	344	422	485	548	594	640	688	768	844
		R. P. M.	915	1290	1585	1830	2050	2240	2420	2580	2890	3170
		B. H. P.	.029	.082	.149	.230	.320	.422	.532	.656	.910	1.16
1½	9	CU. FT.	350	500	610	700	790	860	930	1000	1110	1220
		R. P. M.	762	1076	1320	1524	1700	1866	2020	2152	2408	2640
		B. H. P.	.042	[illegible]	.216	.333	.463	.610	.77	.95	1.32	1.73
2	12	CU. FT.	625	880	1080	1250	1400	1530	1650	1770	1970	2170
		R. P. M.	572	808	990	1145	1280	1400	1512	1615	1808	1980
		B. H. P.	.074	.208	.381	.588	.82	1.08	1.36	1.66	2.32	3.05
2½	15	CU. FT.	973	1380	1690	1950	2180	2400	2590	2760	3080	3390
		R. P. M.	456	645	790	912	1020	1120	1210	1290	1444	1580
		B. H. P.	.115	.326	.600	.923	1.29	1.69	2.14	2.61	3.65	4.8
3	18	CU. FT.	1410	1990	2440	2820	3160	3450	3720	3990	4450	4880
		R. P. M.	381	538	660	762	850	933	1010	1076	1204	1320
		B. H. P.	.167	.470	.862	1.33	1.85	2.43	3.07	3.75	5.25	6.9
3½	21	CU. FT.	1925	2710	3310	3850	4290	4700	5070	5420	6060	6620
		R. P. M.	326	462	565	652	730	800	854	924	1032	1130
		B. H. P.	.227	.640	1.17	1.81	2.53	3.33	4.18	5.11	7.15	9.4
4	24	CU. FT.	2500	3540	4340	5000	5600	6120	6620	7080	7900	8650
		R. P. M.	286	404	495	572	640	700	756	807	904	990
		B. H. P.	.296	.832	1.53	2.35	3.28	4.32	5.44	6.64	9.3	12.2
4½	27	CU. FT.	3175	4490	5500	6350	7100	7780	8400	8980	10050	11000
		R. P. M.	254	359	440	508	568	622	672	718	804	880
		B. H. P.	.373	1.05	1.94	2.98	4.16	5.48	6.90	8.44	11.8	15.5
5	30	CU. FT.	3910	5530	6770	7820	8750	9600	10350	11050	12350	13550
		R. P. M.	228	322	395	456	510	560	604	645	722	790
		B. H. P.	.460	1.30	2.40	3.68	5.15	6.75	8.53	10.4	14.5	19.1
6	36	CU. FT.	5650	7950	9750	11300	12640	13800	14900	15900	17800	19500
		R. P. M.	190	269	330	381	425	466	504	538	602	660
		B. H. P.	.665	1.87	3.44	5.30	7.40	9.72	12.25	15.0	20.9	27.5
7	42	CU. FT.	7700	10850	13300	15400	17170	18860	20300	21700	24250	26600
		R. P. M.	163	231	283	326	365	400	432	462	516	568
		B. H. P.	.903	2.55	4.69	7.24	10.1	13.3	16.7	20.4	28.3	37.5
8	48	CU. FT.	10000	14150	17350	20000	22400	24500	26500	28300	31600	34700
		R. P. M.	143	202	248	286	320	350	378	403	452	495
		B. H. P.	1.18	3.32	6.10	9.40	13.1	17.2	21.75	26.6	37.1	48.8
9	54	CU. FT.	12700	17950	22000	25400	28400	31100	33600	35900	40200	44000
		R. P. M.	127	179	220	254	284	311	336	359	402	440
		B. H. P.	1.49	4.20	7.75	11.9	16.6	21.9	27.6	33.7	47.1	62
10	60	CU. FT.	15650	22100	27100	31300	35000	38400	41400	44200	49400	54200
		R. P. M.	114	161	198	228	255	280	302	322	361	396
		B. H. P.	1.84	5.20	9.58	14.7	20.6	27.0	34.1	41.6	58.2	76.5
11	66	CU. FT.	18950	26800	32850	37900	42300	46400	50100	53600	60000	65700
		R. P. M.	104	147	180	208	232	254	275	294	328	360
		B. H. P.	2.23	6.30	11.6	17.8	24.9	32.7	41.2	50.4	70.4	92.6
12	72	CU. FT.	22600	31800	39000	45200	50600	55200	59600	63600	71200	78000
		R. P. M.	95	134	165	190	212	233	252	269	301	330
		B. H. P.	2.66	7.48	13.7	21.2	29.6	38.9	49.0	59.8	83.6	110
13	78	CU. FT.	26400	37350	45800	52800	59100	64700	70000	74700	83500	91600
		R. P. M.	88	124	153	176	197	215	233	248	278	305
		B. H. P.	3.10	8.77	16.1	24.8	34.7	45.6	57.5	70.2	98	129
14	84	CU. FT.	30600	43400	53200	61600	68700	75200	81200	86800	97100	106400
		R. P. M.	81	115	142	163	182	200	216	231	256	283
		B. H. P.	3.61	10.2	18.7	28.9	40.4	53.0	66.8	81.7	114	150
15	90	CU. FT.	35350	49800	61000	70500	78800	86400	93300	99600	111200	122000
		R. P. M.	76	107	132	152	170	186	201	214	241	264
		B. H. P.	4.14	11.7	21.5	33.1	46.2	60.7	76.7	93.6	131	172


END ELEVATION
MAIN STEAM PIPE
STEAM CONNECTION TO WATER-HEATER
DIAPHRAGM VALVE
WATER-HEATER
SUCTION-PIPE FROM LOWER TANK
THREE-WAY DIAPHRAGM VALVE
PUMP
MOTOR
WATER CONNECTION TO SPRAY PIPES
POT STRAINER
SPRAY PIPES
WATER RETURN PIPE FROM UPPER TANK
OVER FLOW CONNECTION
DRAIN TO SEWER
FRESH WATER PIPE
STEAM CONNECTION TO HEATER COILS
DRAIN
AIR TANK
PUMP
PRESSURE GAUGE
THERMOSTAT FOR CONTROLLING HUMIDITY
ROOM-THERMOSTAT FOR TEMPERATURE
AIR FILTER
BRINE INLET
OUTLET
BLOWER
HEATER COILS
PLAN
HUMIDIFIER AND AIR WASHER
SIDE ELEVATION
THERMOMETER
AIR INLET

The character of the building and the purpose for which it is built must be carefully studied. What answers for one type of building is totally unsuited to another of a different type. Again what serves nicely in a building of a certain type, in which a particular class of work is done, often proves anything but satisfactory in a building of the same type in which a different kind of work is done; for example, compare a machine shop with a paper mill.

Both are similar in size, shape and exposure. In the machine shop no steam or moisture is emitted to condense on the walls and roof, whereas tons of water is thrown off into the air in a paper mill every day which must be taken care of by the amount and distribution of air circulated.

Then, aside from the work done inside the building, the character of design and construction influence the distribution of heat and air.

The tendency to build lofty industrial buildings with steel frames, narrow pilasters and shallow panels of brick or concrete beneath the windows, which fill most of the space between the pilasters, results in enormous surface exposures that conduct away heat very rapidly, thus producing an unbearable downward circulation of cold air near the outside walls, which has to be neutralized or counteracted by the distributing system.

The modern shop has a trussed roof, the bottom chords of which are often 30 to 50 feet above the floor. The ducts have to rest on these trusses and it is impossible to drive air from them down to the floor in a way that will produce satisfactory results. This method has been tried often enough, but there still remain others who must be convinced of its impracticability by trying it themselves. The only way to obtain an even distribution of heat, is to discharge heated air at such points as it is most needed and where the effect will be most appreciated.

To distribute the heat evenly necessitates running the ducts to all cold spots; it is needed the most in the lower strata near the floor, not up among the roof trusses; the greatest benefit is derived from the system by diffusing the warm air close to the floor, keeping the lower strata in circulation and thereby warming it by mixing with it the warm air discharged from the ducts.

The best way to bring this about is to extend the branch ducts from the main trunk line over to the walls or to posts not more than 20 feet away from the outside walls; then down toward the floor, ending four or five feet from the floor. The air should discharge directly toward the floor or at only a slight angle from perpendicular. This method will be found most effective in machine shops, foundries and other lofty structures.

In paper mills, rubber works, dye houses and other plants for which the building is of the same type as those just noted, it is necessary to blow some hot air out towards the roof as well as down towards the floor, in order to take care of the condensation which would otherwise collect on the under side of the roof. Even then, in very cold climates, it is sometimes necessary to put in a false ceiling to overcome this annoyance, particularly if the roof is built of a material which is a good conductor of heat.

For buildings which are several stories in height, each story being from 10 to 16 feet high, the treatment should be different. With them, it is possible, and sometimes advisable, to introduce the air near the ceiling, blowing downward at an angle of 30 to 45 degrees from horizontal.

Frequently buildings of this character are quite effectively heated from one or two galvanized iron standpipes run up through the middle of the building with outlets into each story. This method is practical in buildings not over 60 feet wide; if the building is not over 100 feet long, one riser will be sufficient.

For cotton, woolen or silk mills it has become almost the universal practice to build vertical warm air flues on the outside face of the pilasters, on both sides of the building. These flues usually have a two-inch air space built into the brick work to insulate them. The air is admitted to each story about eight feet above the floor. Deflecting "mill dampers" regulate the volume of air discharged through each opening. The various flues can be supplied at their base from a main duct built either of masonry or galvanized iron.

For manufacturing plants it is customary to make the trunk line ducts of such an area as will convey the required volume of air at a velocity varying from 1500 to 2400 feet per minute. In high buildings used

for heavy and coarse work, where most of the employees stand or move about considerably, the velocity can be much higher than in shops divided into several stories, or those in which the work is more or less sedentary, like the manufacture of shirts, gloves, etc., where the employees sit all day, simply feeding the material into machines.

Air currents or drafts are of not material moment in the former shops, while in the latter they will produce great discomfort, if not sickness. Therefore, the latter class should have the main ducts of sufficient area to keep the velocity down to 1200 to 1800 feet per minute and the branches should be proportioned to a velocity of 600 to 1200 feet.

Another advantage the blower system possesses, infrequently brought to notice, is the cooling and comforting effect it has in oppressively warm weather in the summer time. Simply running the fan will, of itself, greatly relieve the oppressiveness, and when cold water is circulated through the coils the difference is very noticeable.

To sum up: The proper heating of factory buildings is of as much importance and involves as many problems as anything the manager has to decide. It is as essential as the transmission, tools or light, and very much more complex. It should be considered with the plans of the building and made an integral part of the construction, having in mind all the time the equipment best suited to the type of building and the purpose for which it is built.

Fresh air is essential to life. Man can clothe himself to withstand cold, but he cannot get along without air. The purer it is, the better health he has and the faster and better he can work. Therefore, any heating system which does not provide for fresh air should have no consideration.

Something in the way of a ventilating plant is required where manufacturing processes generate steam, smoke and gases. Cold air only makes bad matters worse, so the ventilation necessarily becomes a part of the heating system.

The subject of the proper temperature to maintain in shops is one that does not receive the careful attention it should. It is, if anything, worse to overheat a shop than to underheat it. A fair average tem-

perature should be arrived at and the heating system be flexible enough to keep the shop comfortable when the temperature outside is above and below average.

The distribution of the heat is very important and must be varied with the nature of the building and the work done within its walls. Consideration must also be given to the air velocities, for the purpose of ventilation.

While the cooling of a building is not of the utmost importance, it certainly has great advantages in many ways, and if a system makes it possible of accomplishment without complication or great expense, it becomes a valuable asset to any plant.

These advantages, more or less amplified in the foregoing, as well as many others which have been covered by various writers, all point to but one system of heating as best adapted to manufacturing plants, and that one is the blower system. While it is quite generally recognized as the best, the proper way to install is not so generally understood, and to give some superficial ideas along this line was what prompted the foregoing.

The ventilation of public buildings, assembly halls, churches, schools, etc., require special study to adapt the system to the plans of the building in a way that will be least offensive architecturally and still provide the proper distribution of fresh air.

The velocities must be much lower in such buildings than is allowable in factories, to avoid noise, drafts, etc. It has become quite the common practice to allow the following velocities to prevail in various parts of the plant:

Heater and tempering coils	800 to 1200 ft. per min.
Main distributing ducts	600 to 900 ft. per min.
Vertical flues	400 to 600 ft. per min.
Registers or grilles	300 to 450 ft. per min.

The velocity of air through the fan discharge can be anywhere from 1500 to 2500 feet per minute. The velocity of the tips of the fan blades should never exceed 4000 feet for absolutely noiseless operation.

The amount of air required in public buildings is usually dependent upon the number of occupants, and this is generally far in excess of the amount which would be required to heat it, if considered strictly as a heating problem.

Space herein available will not permit covering public buildings in detail. Volumes have been published on the ventilation of buildings under this classification, to which the inexperienced should refer for a broader knowledge of the subject, as this article is intended to cover the practical side and not the theoretical aspect of the subject.

Ventilation, Gravity System.

When the amount of air required per hour is known, the following rules may be used for low-pressure steam systems:

,02056 H. U. required to heat 1 cu. ft. of air 1°.
1.439 H. U. required to heat 1 cu. ft. of air 70°.
Total H. U. required ÷ 350 = sq. ft. indirect steam radiation for 1st floor.
Total H. U. required ÷ 325 = sq. ft. indirect steam radiation for 2d floor.
Total H. U. required ÷ 500 = sq. ft. indirect steam radiation for 3d floor.
Velocity at all registers 3 to 4 feet per second.
Velocity in heat flues 1st floor 3 to 4 ft. per second.
Velocity in heat flues 2d floor 5 ft. per second.
Velocity in heat flues 3d floor 6 ft. per second.
Velocity in heat flues 4th floor 7 ft. per second.
Velocity in vent. flues 1st floor 6 ft. per second.
Velocity in vent. flues 2d floor 5 ft. per second.
Velocity in vent. flues 3d floor 4 ft. per second.
Velocity in vent. flues 4th floor 3 ft. per second.

The cubic feet of air per hour divided by velocity per hour = area of flue in square feet.

When the temperature of steam is 216°, cold air enters at 0°, the total heat-units given off per square foot indirect steam radiation per hour = 486.

The above rules are based on what may be expected at registers in rooms in which they are located. If a velocity of 6 feet per second is maintained, a square foot of indirect radiation emits 3.25 heat-units per hour per degree difference between the temperature of steam and surrounding air at radiator. This may be taken as the limit of work for a square foot of indirect steam radiation with natural draft.

To determine boiler capacity divide the total heat-units required for all work by 280; the result will be the work equivalent in direct steam radiation, as per the conditions on which boilers are rated by the manufacturer.

Amount of Air Used for a Blower System for Ventilation.

	Cubic feet per hour.
Hospitals	3,600 per Bed.
Legislative Assembly Halls	3,600 per Seat.
Barracks, Bedrooms and Workshops	3,000 per Person.
Schools and Churches	2,400 per Person.
Theaters and Ordinary Halls of Audience	2,000 per Seat.
Office Rooms	1,800 per Person.
Dining Rooms	1,800 per Person.
Toilet and Bath Rooms	2,400 per Fixture.

Making Tight Screwed Joints for Very High Pressure.

If the ordinary steam fitter was called upon to put up piping that should stand 200 or 300 pounds of steam pressure, I think he would feel that he was taking a very large responsibility, and if he was called upon to do a job that should stand 1,000 pounds of air pressure he would not feel like taking this responsibility, and any one taking this responsibility would feel that he was obliged to resort to very extraordinary means in order to accomplish such a result, and if called upon to do such work with the ordinary material that is manufactured and supplied in the general market, he would say that it was an impossibility to do it.

Friction is due to the large amount of surface, especially when the joints are coming up close to a bearing. Any grit or gummy material in the joint also tends very largely to produce friction. Friction produces expansion, and as the pipe is lighter than the coupling it expands more than the coupling, and then when both again become cool the pipe shrinks more than the coupling, thus causing a tendency to leak.

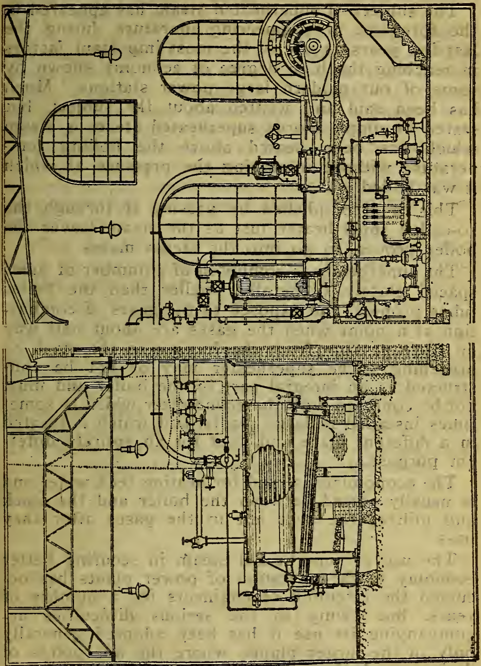
It is of course evident to anyone who has given any thought whatever to this subject, that in order

to make tight such joints as are mentioned above, the iron must be brought together as solidly as possible.

To get such results it is imperatively necessary that the iron should be absolutely clean, and then it is essential that the very best lubricant is used in order to reduce the friction.

Would also add, that we have discovered that, in order to produce good joints, it is not necessary that the threads should be absolutely perfect, nor is a taper essential nor is a large amount of bearing necessary; in fact, we made one joint with a thread reduced to three-fourths of an inch in width, and this joint was tight at 1,500 pounds hydraulic pressure, which proves that the bearing was not essential to the making of a tight joint, and that the length of thread was not essential to prevent stripping of the thread from the coupling or the pipe.

This, I think, also proves another point that is not understood, and that is that it is not essential, in order to do good work, to have especially long threads. In fact, we are satisfied that especially long threads are a detriment in making a good joint, for it stands to reason that such long threads tend to produce friction, which prevents the iron from coming up closely together, and the irregularity of the thread on the pipe tends to prevent the iron coming up in the closest contact. This will be better understood, if we go to a great extreme in the matter. For instance, should we undertake to make a joint on eight-inch pipe, with a thread six inches long, the irregularities and friction would be so great that it would be impossible to get this thread contact.



Typical Layout of Power Plant Showing Combination Boiler, Water Tube, and Tubular, and all Necessary Piping.

Superheated Steam.

The subject of superheated steam has appeared in the forefront of engineering literature during the last few years as one of the most important factors in reaching the high degree of economy shown by some of our modern large power stations. Much has been said and written about the subject, but stated in simple words superheated steam is steam which has been heated above the boiling temperature without increasing the pressure at which it was boiled.

This is accomplished by passing it through the so-called super-heater just as the steam leaves the boiler proper, to go into the steam mains.

The superheater is composed of a number of tubes spaced closely (generally smaller than the boiler tubes proper), and exposed to the gases of combustion at a point when the gases are about half way on their passage from the furnace to the stack or breeching. The superheater may or not be constructed as an integral part of the boiler and must not be confused with the economizer which is sometimes installed in large plants, and which is located in a different place and used for an entirely different purpose.

The economizer is used for heating feed water and is usually placed between the boiler and the stack and utilizes the heat left in the gases after they pass.

The use of superheated steam in securing better economy in the operation of power plants has occupied the attention of engineers for a number of years, but owing to the serious difficulties accompanying its use it has been adopted generally only in the larger plants, where the fine points of design are looked after more carefully.

Superheated steam when used in the steam engine has brought about a remarkable improvement in the steam consumption by reducing the cylinder condensation. (By cylinder condensation is meant that steam when admitted to one end of a cylinder which has just been opened to the exhaust, the walls of

which are comparatively cool, a part of this steam is then condensed to water and is therefore lost as far as useful work is concerned.)

On the other hand the troubles experienced in handling steam at such high temperatures have in many cases more than offset the advantages gained.

For example: Gaskets have leaked and blown out packings have deteriorated and cylinders have been scored under the sudden and wide variations of temperatures which are thus met with. But many of these troubles have now been overcome and the success of the steam turbine as a prime mover has established the use of superheated steam more firmly than ever.

With the steam turbine one of the main advantages in superheating lies in the decreased friction of the steam on the blades of the turbine. Furthermore, the erosion of the blades is reduced to a minimum. The exact gain in economy due to superheating the steam used in steam turbines is as yet not fully determined, but the saving is approximately 1 per cent for each 12½ degrees F. of super heat. After taking into account the increased cost of boiler plant with superheaters, and after allowing for increased cost of maintenance of the plant as a whole, the saving due to the use of superheated steam is beyond question an established fact.

The Blast Unit System of Steam Heating.

In many ways the modern industrial building presents a problem in heating different from any other type of building. The period of occupancy, due to the tendency toward short hours of labor, is probably less than any other type of building. The necessity for a heating plant which will quickly respond is therefore very great. Industrial buildings are usually constructed of glass, through which the heat loss is tremendous. The clear height from floor to roof is usually great, presenting a problem in holding the heat at the lower levels.

In the past, two distinct types of heating apparatus were used for industrial buildings. The most commonly known is the direct steam system. Radiators and pipe coils are usually placed along the exposed walls and roof of the building. This system is advantageous primarily because of its simplicity. Results are largely a matter of sufficient surface, and a system of piping which will carry steam to the different units of radiation. The chief disadvantage of the direct system lies in the fact that the operating cost is excessive because of the tremendous loss by radiation through exposed surfaces. Authorities generally agree that not less than 25 per cent of the total heat generated is lost in this manner. The direct system is also very slow to respond, and in most instances necessitates heat supply over the full twenty-four hours in order to maintain a comfortable temperature through the working hours.

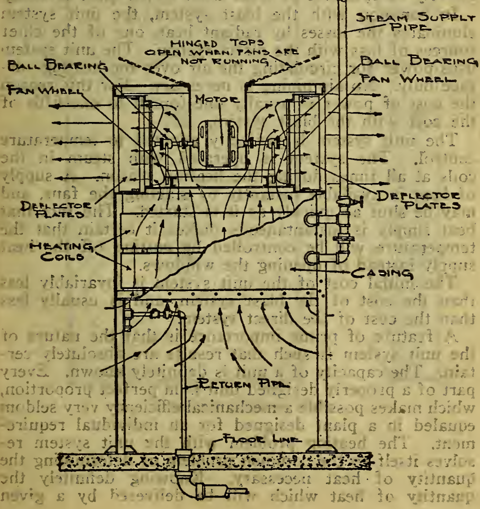
The direct system does not readily lend itself to temperature control. Because of the length of time required to heat up a radiator or coil, and the corresponding length of time required for the same unit to cool, control of temperature by the operation of steam valves is unsatisfactory. In practice the temperature is usually controlled by opening and closing the windows, which is obviously an expensive, wasteful method.

The other type of system is what is commonly known as the blast or indirect system of steam heating. The heating surface is located at one or possibly two points in the building, and the air in the room is circulated over the heating surface by means of a blower. Heated air is distributed throughout the building by means of a system of sheet metal piping. This system overcomes a great many of the disadvantages of the direct system. It eliminates to a great extent the losses by radiation. It readily lends itself to temperature control by means

of the control of air temperature leaving the heating surface.

The disadvantages are that the initial cost of the blast system is considerably greater than the direct system. The cost of motive power for driving the blower is high by reason of the friction to the flow of air in an extended system of air piping. The blast system of this type must be designed for the particular building in which it is placed. This applies to every part of the system. The design of a blast system necessitates the very best of engineering knowledge along these lines. Such factors as the resistance to the flow of air, the probable loss in temperature by connection and radiation from the air piping, must be determined with a reasonable degree of accuracy. The fact that a large percentage of blast systems are faulty is evidence of the care that must be given to the design of such a system.

Because of the large volume of air which must be



handled in a building of any size, the air ducts necessary are correspondingly large, and it is sometimes very difficult to design a blast system so that these ducts do not obstruct light and interfere with shafting, machinery, etc.

The past few years have witnessed the development of a heating system for industrial buildings which, to a very great extent, incorporates the advantages of both the direct and blast systems, with but very few of the objectionable features of either. This system is generally known as the blast unit system of steam heating.

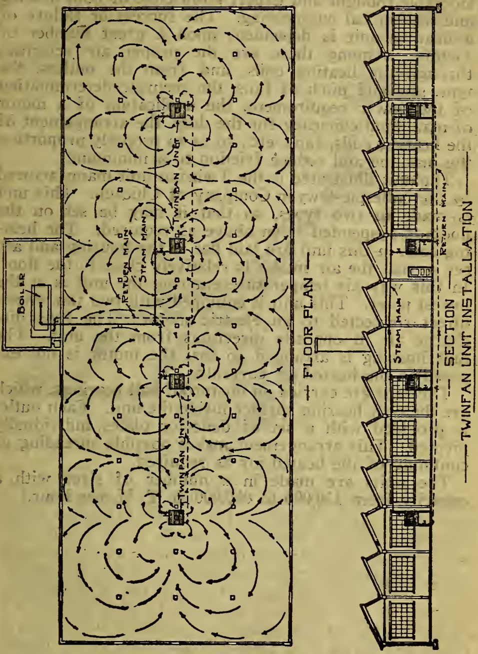
It consists of a number of units of varying size and number to meet the individual requirements. Each unit contains a group of steam coils, together with a motor and fans for distributing the heated air. The units are usually located near the center of the building, and are arranged to discharge heated air towards the exposed walls. Each unit is a complete heating machine in itself, entirely independent of other units in the same building.

In common with the blast system, the unit system eliminates the losses by radiant heat, one of the chief sources of loss with the direct system. The unit system uses power for circulating the air over the heating surface only. No air piping is necessary. For this reason the cost of power is usually one-fourth to one-fifth of the cost with the blast system.

The unit system is perfectly adapted to temperature control. The system is operated with steam in the coils at all times during the heating season. A supply of heat is available instantly by starting the fans, and may be shut as quickly as it is started. The fact that heat supply is instantaneous makes it certain that the temperature will be controlled by cutting off the heat supply instead of opening the windows.

The initial cost of the unit system is invariably less than the cost of the blast system, and is usually less than the cost of the direct system.

A feature of prime importance is that the nature of the unit system is such that results are absolutely certain. The capacity of a unit is definitely known. Every part of a properly designed unit is in perfect proportion, which makes possible a mechanical efficiency very seldom equaled in a plant designed for an individual requirement. The heating problem with the unit system resolves itself to the common problem of determining the quantity of heat necessary. Knowing definitely the quantity of heat which will be delivered by a given



Simplified Heating Plant

unit, it is a very simple matter to determine the size and number of units necessary for any building.

Like any mechanical device, the construction of a unit heater, to be highly efficient, is a matter of considerable thought and expert knowledge of both heating and mechanical engineering. The success or failure of a heating unit is dependent upon a great number of factors. Among these are the proper air velocities through the heating coils, and from the outlets, the type, size and pitch of fans, the accurate determination of the power requirement, the application of a motor of maximum efficiency for the duty, the arrangement of the heating coils, fans, etc., so as to properly proportion the machine and reduce friction to a minimum.

The unit illustrated is the Twinfan unit manufactured by the Gillespie-Dwyer Company of Chicago. This unit is made in two types, so that it may be set on the floor or suspended from above as required. The heating coils in this unit are laid flat in the housing and are set so that the air intake is relatively close to the floor. In this way air temperature entering the unit is at the lowest point. This unit is equipped with two fan wheels direct connected to an electric motor. The fans discharge air in opposite directions from the unit. The unit housing is arranged so that the motor is not exposed to the heated air currents.

The fans are carried on dustproof ball bearings, which are the only bearing surface inside the unit. Each outlet is provided with a set of deflector plates individually pivoted. This arrangement makes possible spreading or confining of the heated air as required.

The units are made in a number of sizes with a capacity from 150,000 to 650,000 B. T. U. per hour.

How to Construct Long Horizontal Flow Mains in Hot Water Heating Plants.

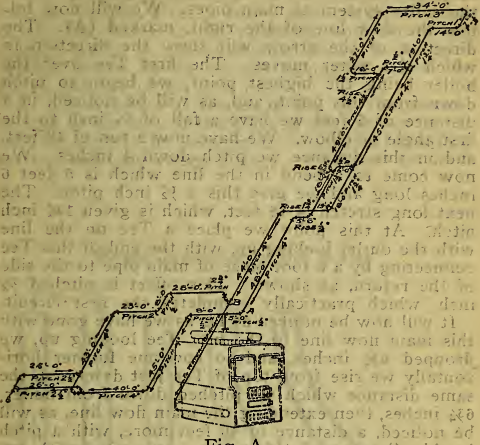


Fig. A.

In constructing hot water heating plants for scattered buildings, where all radiatior is supplied from one boiler or a group of boilers coupled together, there must be some careful calculations made in the laying out of pipe work in order to secure a good circulation at all points throughout the plant. And, for the purpose of showing how this can be done in a successful manner, we make use of plate Fig. A, which is the working drawing of a large hot water heating plant now in operatiton and giving the most satisfactory results.

We merely show in plate Fig. A the cellar mains connected to the boiler, but branches are taken from top of flow lines to the various radiators and risers with returns carried back to side of same flow lines.

Referring to the plan, it will be observed that the main flow from boiler connects with a Tee which separates the flow water to each side of the boiler as it is located. This Tee is the highest point in the cellar system of main pipes. We will now follow the flow line of the right, marked (A). The direction of the arrow will show the direction in which the water moves. The first Tee over the boiler being the highest point, we begin to pitch down from this point, and, as will be noticed, in a distance of 5 feet we have a fall of ½ inch to the first angle or elbow. We have now a run of 48 feet, and in this distance we pitch down 4 inches. We now come to a bend in the line which is 5 feet 6 inches long and we give this a ½ inch pitch. The next long stretch is 18 feet, which is given 1¾ inch pitch. At this point we place a Tee on the line with the outlet looking up, with the end of this Tee connecting by a 6 foot piece of main pipe to the side of the return, as shown. This offset is pitched ½ inch, which practically completes the first circuit.

It will now be noticed as far as we have gone with this main flow line to the first Tee looking up, we dropped 6¾ inches, and to continue further horizontally we rise from top of Tee just described, the same distance which we pitched down from boiler, 6¾ inches, then extending the main flow line, as will be noticed, a distance of 46 feet more, with a pitch in this distance of 4½ inches, connecting with another Tee, we rise again the distance which we dropped in the last run, which is 4½ inches, and, connecting the end of Tee to the side of return pipe, thus completing a second circuit in the main lines.

The main flow line is pitched down again from the last 4½ inch rise as indicated, making the last circuit on the extreme end of the system and gradually pitching back to the return connectiton of boiler. (B) represents the main return pipe in the system, and, referring again to the pipe work on the left of boiler, the same general method is carried out, forming separate circuits according to the distance and conditions of the building yet with only one flow and one return pipe connecting with the boiler. It is advisable to place air valves or air

pipes at all high points on main flow lines, so that any air that may accumulate at such points, can be drawn or allowed to escape.

This system of dividing the main flow line into various circuits gives a more uniform distribution of the hot water to the radiation, and allows the coldest water in the system to move back more rapidly to the boiler, by not having to travel the entire distance of the flow line.

In pipe systems as shown in Fig. A, the proportioning of the size of the pipes at the various points for the work to be performed, is also an important matter, and long sweep fittings only should be used.

Rapid Circulation of Hot Water

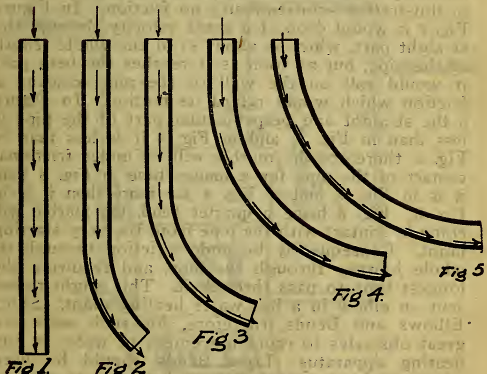


Fig. B.

Rapid Circulation of Hot Water.

A simple manner of illustrating friction in the flow of water through pipes at various angles is shown in the accompanying illustration, which represents 5 pipes standing on end. If we drop a marble into each pipe, and take notice of the time that it take the marble to travel through each pipe we will find that the marble dropped into the straight pipe will reach the bottom in the shortest time. The marble dropped into the quarter bend pipe, Fig. 5, will require the longest time. If these pipes were of glass we would notice—we will say for illustrating it—that the marble dropped into the straight pipe, marked Fig. 1, would travel through this straight and perpendicular pipe without touching the wall of the pipe—as shown by arrows in illustration—consequently no friction. In Figure Fig. 2 it would drop at a great velocity through the straight part, which is about ⅔ of the whole length of the pipe, but as soon as it reaches the bent part it would roll on the wall of the pipe, causing a friction which would retard its motion. In Figure 3 the straight and perpendicular part of the pipe is less than in Fig. 2, and in Fig. 4 it is less than in Fig. 3, therefore the marble will be under frictional contact of the pipe for a longer time in Fig. 3 than it is in Fig. 2, and in Fig. 4 far more than it is in Fig. 3. Fig. 5 being a quarter bend, the marble will come in contact with the pipe from the very starting point. Consequently be under friction through its whole journey through the pipe, and requiring the longest time to pass through it. This might represent an elbow in a hot water heating plant. Short Elbows and Bends, therefore, for such work are great obstacles to rapid movement of water in any heating apparatus. Long Bends should be used where angles are necessary, in branches as well as in elbows.

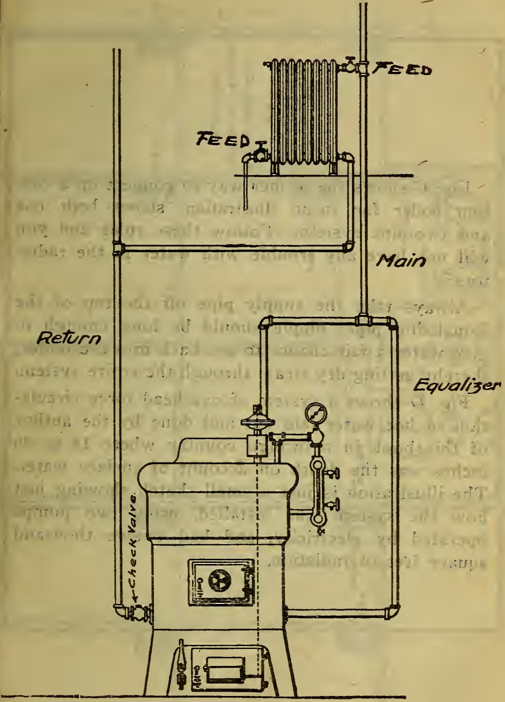


Fig. C.

Typical Connection for Steam Heating

Fig. C shows the proper way to connect up a cast iron boiler for steam illustration shows both one and two-pipe system. Follow these rules and you will not have any trouble with water in the radiators.

Always take the supply pipe off the top of the Equalizing pipe; nipple should be long enough to give water a fair chance to get back into the boiler, thereby getting dry steam through the entire system.

Fig. D shows a system of overhead force circulation of hot water laid out and done by the author of this book in a foreign country where 18 to 20 inches was the depth on account of surface water. The illustration is just a small sketch showing just how the system was installed, using two pumps operated by electricity, and had twelve thousand square feet of radiation.

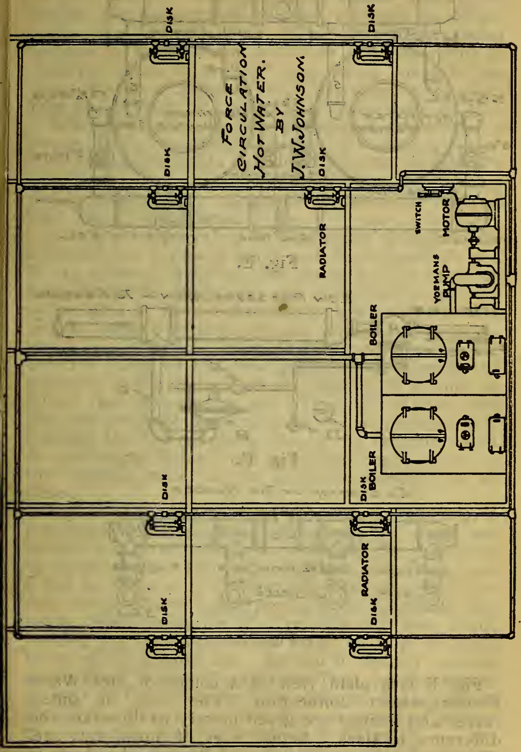

FORCE CIRCULATION HOT WATER. BY J.W.JOHNSON.
DISK
RADIATOR
SWITCH
MOTOR
YOEMANS PUMP
BOILER

Fig. D.

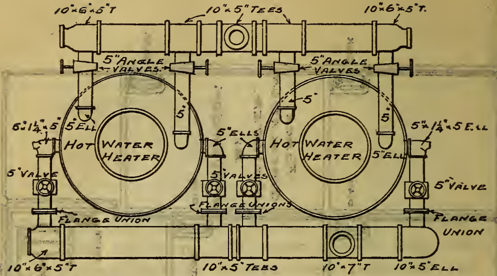


Fig. E.

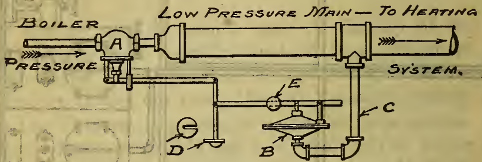


Fig. F.

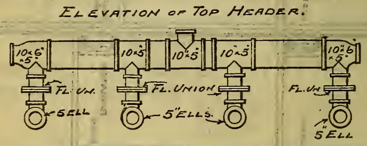


Fig. G.

Fig. E is a plain view of a couple of Hot Water Heaters,—twin connection. The size of pipes, valves and fittings are given merely to illustrate the difference in sizes. Actual sizes of pipes, etc., are, of course, governed by size of heaters. As there is not much expansion in water the header should be of an area equivalent to the area of the connections

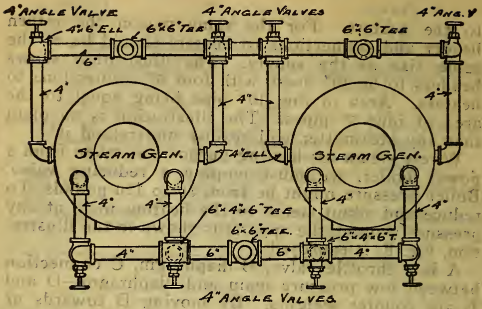
to the heaters. For the same reason the return header and connections to heaters should be of the same size as the supply. The illustration shows headers to be 10″ diam. with four 5″ connections to heaters. Area of one 10″ pipe being equal to the area of four 5″ pipes. The illustration is so plain that any steamfitter will readily understand it.

Where steam for heating purposes is taken from a power boiler, we must employ a reducing valve. Boiler pressure might be from 80 to 120 pounds. To reduce and admit steam to the heating main at any pressure wanted, the apparatus shown in the illustration, Fig. F, is employed.

A is a throttle valve, B diaphragm, C connection between low pressure main and diaphragm—D and E are counter weights. By moving D towards or away from the diaphragm and taking off or putting on weights at D, the pressure in low pressure main can be reduced to any pressure wanted. The working is as follows: Steam is admitted through the throttle valve to the low pressure main until the pressure in the main is of the number of pounds to which the apparatus is set. Then the steam from the low pressure main acts on the diaphragm and, through the levers, partly closes the throttle valve. A diaphragm, being very sensitive, keeps steam in the heating main at the pressure wanted, at all times.

Fig. H is a plain view of a couple of steam generators,—twin connection. The size of pipes and fittings are given merely to illustrate the difference in sizes. Actual sizes of pipes are, of course, governed by the size of generators required. Fig I is a side elevation, on larger scale, showing steam and return pipes—from the 6″ Tee, Fig. H, with outlet looking up, connection is made to one or more loops of the supply line. Return to boilers is made at the 6″x6″ Tees. Close to the Tees, for the supply as well as for the return connections, flange unions should be inserted so that disconnection of boilers can be made without breaking a fitting.

The advantage of two boilers is: that in Spring and Fall, when just a little heat is required, one boiler only needs to be in use, thereby saving in fuel.


4" ANGLE VALVE
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6"x6" TEE
4" ANGLE VALVES
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4" ANGLE VALVES.

Fig. H.

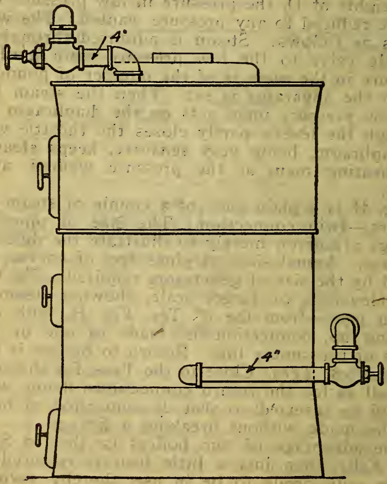
4"
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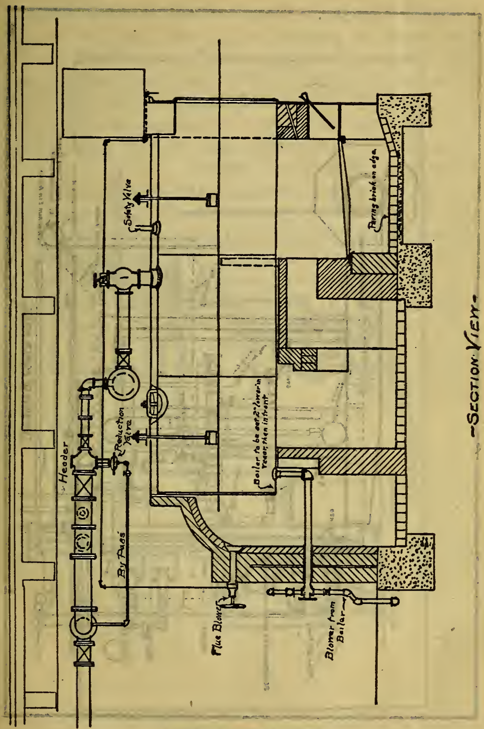
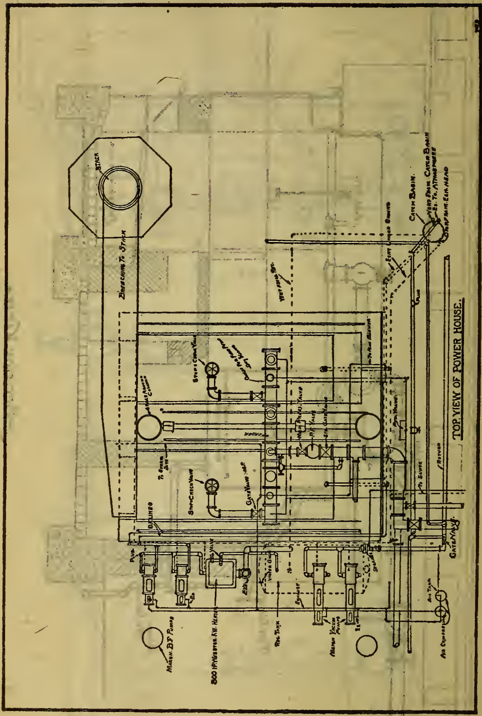
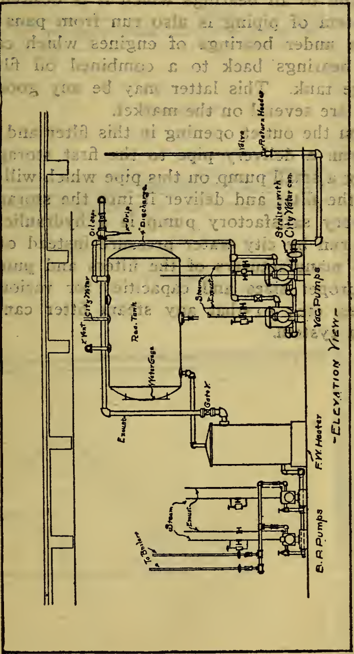
Fig. I.



High Pressure Work



High Pressure Work



High Pressure Work

High Pressure Lubricating System.—Fig. 40.

An oil storage tank is placed at a convenient location above the engines and piping from the storage tank run to all bearings which it is desired to oil. A system of piping is also run from pans or bed frames under bearings of engines which catch oil from bearings back to a combined oil filter and storage tank. This latter may be any good make. There are several on the market.

From the outlet opening in this filter and storage tank run a delivery pipe to the first storage tank, placing a small pump on this pipe which will pull oil from the filter and deliver it into the storage tank.

A very satisfactory pump is a hydraulic duplex pump run by city water pressure instead of steam.

The manufacturers of the filters and pumps will give proper sizes and capacities for various sized engines, etc., so that any steam fitter can put in such a system.

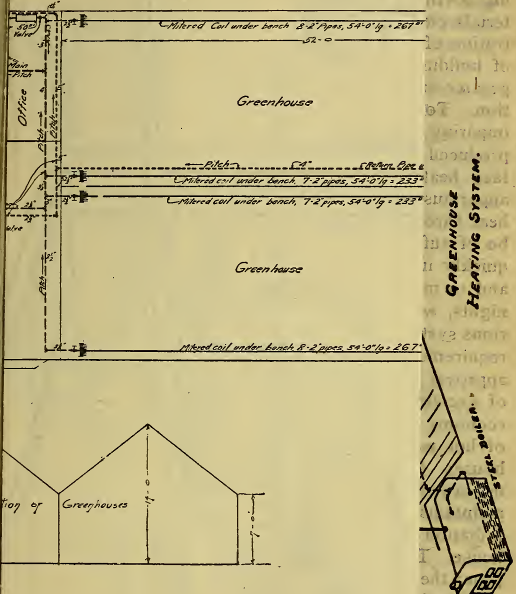
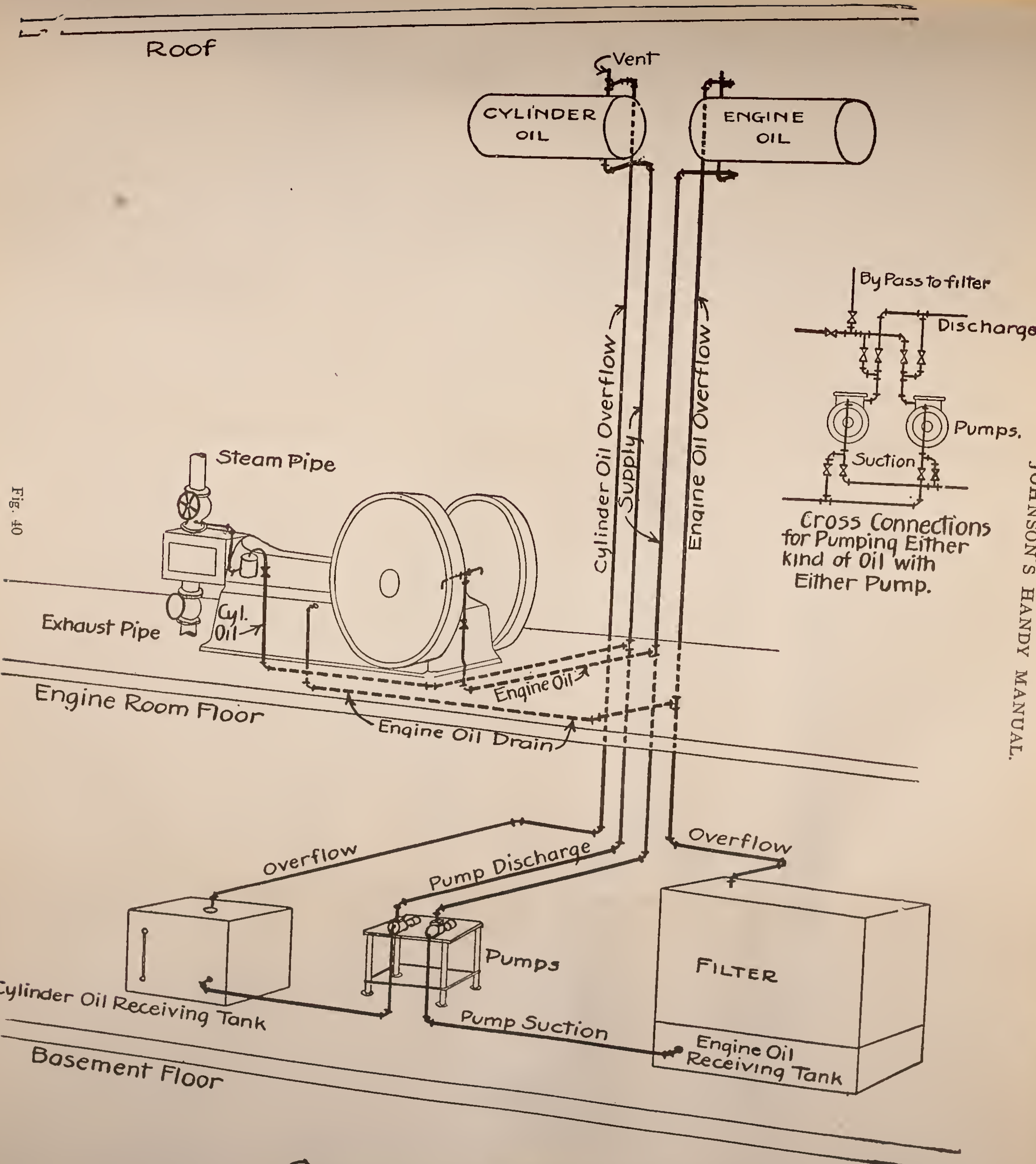

Mitered Coil under bench 8-2" Pipes, 54'-0" lg = 267"
52'-0
Greenhouse
Office
Main
Pitch
Valve
Pitch
4"
Return Pipe
Mitered coil under bench, 7-2" pipes, 54'-0" lg = 233"
Mitered coil under bench, 7-2" pipes, 54'-0" lg = 233"
Green house
Mitered coil under bench 8-2" pipes, 54'-0" lg = 267'
Greenhouses
14'-0
7'-0
STEEL BOILER
GREENHOUSE HEATING SYSTEM.

Fig. 40



GRAVITY OILING SYSTEM.

High

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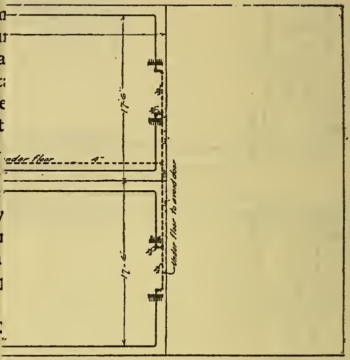


HEATING PLAN OF GREENHOUSE

—BY—

JOHN W. JOHNSON
802 STEWART BLDG. CHICAGO, ILL.
Scale-1/8"=1 ft

Greenhouse Heating System.

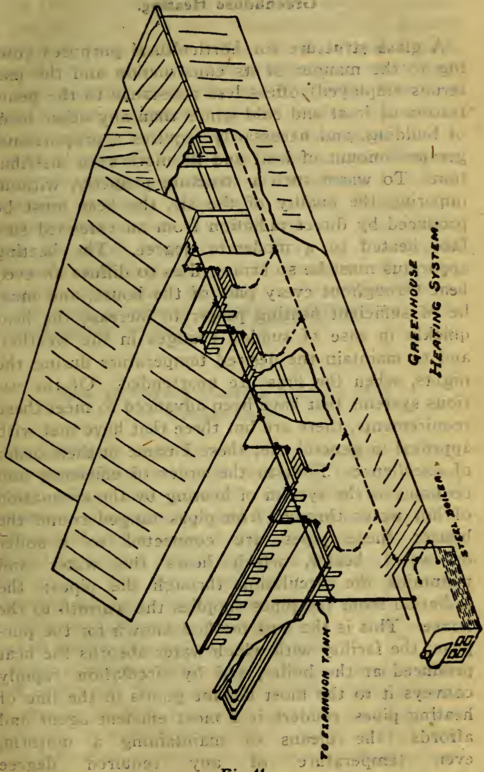
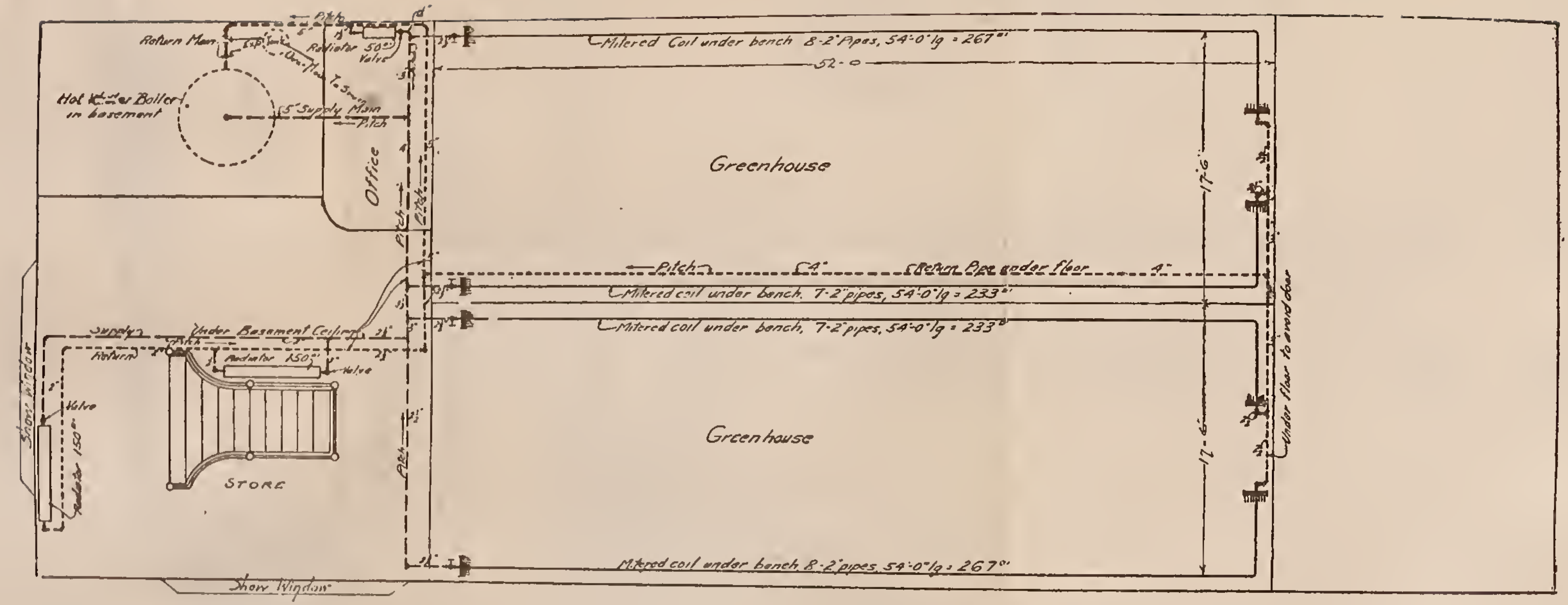
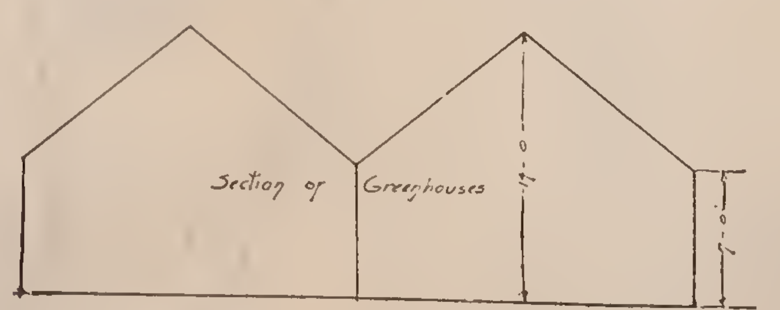


Fig. 41.





HEATING PLAN OF GREENHOUSE

BY

JOHN W. JOHNSON

802 STEWART BLDG. CHICAGO, ILL.

Scale $\frac{1}{8}$" = 1 ft

Greenhouse Heating.

A glass structure for horticultural purposes (owing to the manner of its construction and the materials employed) offers less resistance to the penetration of frost and cold winds than any other form of building, and necessarily requires a proportional greater amount of heat and its more even distribution. To warm such a structure properly, without imparing the quality of the air, the heat must be produced by direct radiation from an extended surface heated to a moderate degree. The heating apparatus must be so arranged as to diffuse an even heat throughout every part of the house, and must be of sufficient heating power to increase the heat quickly in case of sudden changes in the weather, and to maintain the desired temperature during the nights, when the fires are unattended. Of the various systems that have been advanced to meet these requirements, there are but three that have met with approval in general use; these I name in their order of excellence. First in the order of efficiency and economy is the system of heating by the circulation of hot water through iron pipes ranged round the house; these pipes are connected to a boiler or water heater, which heats the water and maintains the circulation through the pipes; the radiation from the pipes supplies the warmth to the house. This is the best method known for the purpose; the facility with which water absorbs the heat produced at the boiler, and by circulation, rapidly conveys it to the most distant points in the line of heating pipes, renders it a most efficient agent and affords the means of maintaining a uniform, even temperature of any required degree throughout all parts of the house; with a mild and

humid atmosphere, which is congenial to the healthy growth and perfection of plants, flowers and fruits, while the substantial, enduring and reliable qualities of the apparatus, the easy managements and perfect control of heat in the house, or in several houses heated by the same fire, the number of hours it may be left without attention, and the entire freedom from deleterious gases, dust and smoke, are among the advantages fairly claimed for the system.

It is so universal in its application, and offers so many advantages over every other system, that it is generally adopted, both here and in Europe, for heating plant houses of every size and description, from the small home conservatory to the largest botanical structures, and will be found in use, to the exclusion of all other methods, in the establishments of the most prominent and successful horticulturists throughout the country.

How to Figure Heating Surface of a Greenhouse.

In figuring a greenhouse we have to deal entirely with exposed surface, cubic contents, rarely, if ever, being taken into account; therefore, the entire amount of glass exposed and its equivalent should be determined, and in doing this the ends and side walls should be figured just as surely as the overhead and end glass. The sides and end walls, if of wood, sheathed and papered good and tight, should be figured in the following proportions, viz: Five square feet of wall to one square foot of glass.

After obtaining the number of square feet of glass and equivalent, the next point is the proper amount of heating surface necessary, and this is dependant upon the temperature required in the greenhouse. The following proportions of glass to heating surface will be found fully accurate.

	St.	H.W.
To a temperature of 40° divide No. sq. ft. of glass by	9	6
To a temperature of 45° divide No. sq. ft. of glass by	8	5
To a temperature of 50° divide No. sq. ft. of glass by	7	4
To a temperature of 55° divide No. sq. ft. of glass by	6½	3¾
To a temperature of 60° divide No. sq. ft. of glass by	6	3½
To a temperature of 65° divide No. sq. ft. of glass by	5½	3¼
To a temperature of 70° divide No. sq. ft. of glass by	5	3

The above is based on an outside temperature of zero.

Lubricating System.

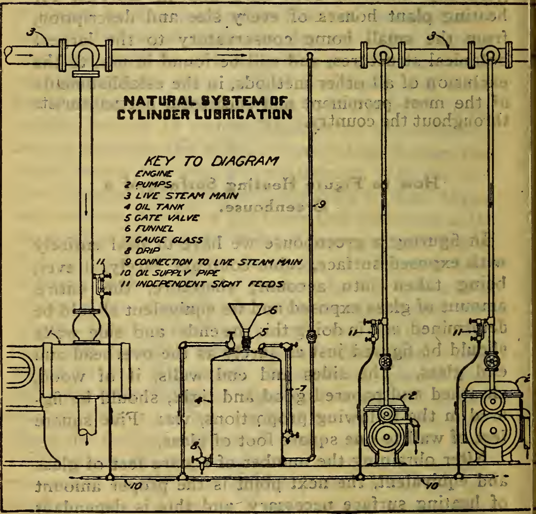


Fig. 39.

Expansion and Contraction.

Scarcely anything can withstand the expansion of iron. It expands from 32° to 212°, about 1-900 of its length, which in 100 feet equals 1 3/8 inches. The expanding power of a 2″ pipe when heated to a temperature of 100 pounds steam, or 338°, exerts a force sufficient to move 25 tons.

Cast iron expands 1/162000 of its length for each degree Fahr. It is subjected to within ordinary limits while in its solid state.

Wrought iron expands 1/150000 of its length for each degree Fahr. To find the expansion of a line of pipe, multiply its length in inches by the number of degrees of temperature applied and divide the product by 150,000 for required expansion in inches; thus $100' \times 12'' = 1200 \times 338° = 405600 \div 150000 = 2.7$ inches.

Special attention, then, must be given to the expansion and contraction of pipes and allowance made for it.

Expansion joints should not be used if the expansion can be compensated for in any other way.

		PRESSURE STAND PIPE	
Allow for thread to screw tight in fitting	Size of opening for tapping (inches)	Bursting pressure (pounds)	Working pressure factor Safety 6 (pounds)
5/16	11/32	25,182	4,197
3/8	29/64	24,174	4,029
3/8	19/32	18,420	3,070
9/16	23/32	17,490	2,915
9/16	15/16	13,704	2,284
5/8	1 3/16	12,780	2,130
5/8	1 1/2	10,140	1,690
3/4	1 3/4	9,000	1,500
3/4	2 3/16	7,000	1,240
7/8	2 11/16	8,262	1,377
7/8	3 5/16	7,080	1,180
7/8	3 13/16	6,366	1,061
1	4 5/16	5,880	980
1	4 3/4	5,460	910
1 1/8	5 5/16	5,130	855
1 1/8	6 5/16	4,614	769
1 1/4	7 3/8	4,290	715
1 1/4	8 3/8	4,926	671
1 1/2	9 5/8	3,846	641
1 5/8	10 7/16	3,648	608
1 3/4	12 15/32	3,120	520

Useful Information

Steam.

A cubic inch of water evaporated under ordinary atmospheric pressure is converted into 1 cubic foot of steam (approximately).

The specific gravity of steam (at atmospheric pressure) is .411 that of air at 34 Fahrenheit, and .0006 that of water at same temperature.

27,222 cubic feet of steam weigh 1 pound; 13,817 cubic feet of air weigh 1 pound.

Locomotives average a consumption of 3,000 gallons of water per 100 miles run.

The best designed boilers, well set, with good draft, and skillful firing, will evaporate from 7 to 10 lbs. of water per pound of first-class coal.

In calculating horse-power of tubular or flue boilers, consider 15 square feet of heating surface equivalent to one nominal horse-power.

On one square foot of grate can be burned on an average from 10 to 12 lbs. of hard coal, or 18 to 20 lbs. soft coal, per hour, with natural draft. With forced draft nearly double this amount can be burned.

Steam engines, in economy, vary from 14 to 60 lbs. of feed water and from 1½ to 7 lbs. of coal per hour per indicated H. P.

Rules for Calculating Speed of Pulleys.

1. The diameter of the driver and driven being given, to find the number of revolutions of the driven:

Rule. Multiply the diameter of the driver by its number of revolutions, and divide the product by the diameter of the driven; the quotient will be the number of revolutions.

2. The diameter and the revolutions of the driver being given to find the diameter of the driven, that shall make any given number of revolutions in the same time:

Rule. Multiply the diameter of the driver by its number of revolutions, and divide the product by the number of revolutions of the driven; the quotient will be its diameter.

3. To ascertain the size of the driver:

Rule. Multiply the diameter of the driven by the number of revolutions you wish to make, and divide the product by the revolutions of the driver; the quotient will be the size of the driver.

A gallon of water (U. S. Standard) weighs 8⅓ pounds, and contains 231 cubic inches.

A cubic foot of water weights 62½ pounds, and contains 1,728 cubic inches, or 7½ gallons.

Each Nominal Horse-Power of boilers requires 1 cubic foot of water per hour.

In calculating horse-power of steam boilers, consider for tubular or flue boilers 15 square feet of heating surface equivalent to 1 horse-power.

Condensing engines require from 20 to 25 gallons of water to condense the steam evaporated from one gallon of water.

To find the pressure in pounds per square inch of a column of water, multiply the height of the column in feet by .434. (Approximately, every foot elevation is called equal to one-half pound per square inch.)

To find the capacity of a cylinder in gallons. Multiply the area in inches by the length of stroke in inches will give the total number of cubic inches; divide the amount by 231 (which is the cubical contents of a gallon in inches), and the product is the capacity in gallons.

Ordinary speed to run pumps is 100 feet of piston per minute.

To find quantity of water elevated in one minute running at 100 feet of piston per minute. Square the diameter of water cylinder in inches and multiply by 4. Example: Capacity of a five-inch cylinder is desired; the square of the diameter (5 inches) is 25, which, multiplied by 4, gives 100, which is gallons per minute (approximately).

To find the diameter of a pump cylinder to move a given quantity of water per minute (100 feet of piston being the speed), divide the number of gallons by 4, then extract the square root, and the result will be the diameter in inches.

To find the velocity in feet per minute necessary to discharge a given volume of water in a given time, multiply the number of cubic feet of water by 144, and divide the product by the area of the pipe in inches.

To find the area of a required pipe, the volume and velocity of water being given, multiply the number of cubic feet of water by 144, and divide the product by the velocity in feet per minute. The area being found, it is easy to get the diameter of pipe necessary.

The area of the steam piston multiplied by the steam pressure, gives the total amount of pressure exerted. The area of the water piston, multiplied by the pressure of water per square inch, gives the resistance. A margin must be made between the power and the resistance, to move the pistons at the required speed; usually reckoned at about 50 per cent.

Every pound of coal requires a definite amount of air to burn it. It therefore requires ten times as much air to burn properly one hundred pounds of coal as it does to burn ten, and so on. Don't try to do what is impossible; a boy may sometimes be made to do a man's work, but a small chimney cannot possibly do the work of a large one.

The Boiling Point of Water.

Water boils at different temperatures, according to the elevation above the sea level. In New York water boils practically at 212 degrees Fahrenheit; in Munich, Germany, at 209½ degrees; in the City of Mexico, at 200 degrees, and in the Himalayas, at an elevation of 18,000 feet above the level of the sea, at 180 degrees. These differences are caused by the varying pressure of the atmosphere at these points. In New York the whole weight of the air has to be overcome.

In Mexico, 7,000 feet above the sea, there is 7,000 feet less of atmosphere to be resisted; consequently less heat is required and boiling takes place at a lower temperature.

Under no consideration should ¾-inch pipe be used in any kind of hot water heating systems. Use 1-inch or larger in all cases.

Condensed Rules for Calculating Boiler Horse-Power.

Under Favorable Conditions. A flue boiler will evaporate 2 lbs. of water per hour per square foot of heating surface. Now, as the evaporation of 30 lbs. of water per hour into steam of 70 lbs. gauge pressure, when feed water has a temperature of 100° F., constitutes a horse-power, then each 15 square feet of heating surface in this type of boiler, with good coal and good draft, will generate a horse-power.

Tubular and water tube boilers can be made to furnish a horse-power for each 12 feet of heating surface. Locomotive boilers will develop 1 horse-power for each 8 square feet of heating surface. Under average conditions, with feed water at 100° F., and steam at 70 lbs. gauge pressure, and 3,000 lbs. of water be evaporated in one hour in any boiler above mentioned, then 3,000 ÷ 30 = 100 horse-power developed by that boiler. In

actual practice, however, the conditions must be reduced to the standard given, as follows:

RULE—Multiply the total heat of steam at pressure carried (minus temperature of feed water) by the lbs. of water evaporated per hour and divide by 1,100 (British thermal unit), the quotient will be the lbs. of water evaporated with feed water at 100° F. and a steam pressure of 70 lbs. Now ÷ again by 30 = the horse-power developed.

PROBLEM—The steam pressure being 90 lbs. and feed water 210° F., and 3,400 lbs. of water being evaporated per hour, what is the horse-power? Referring to steam table we find that 90 lbs. gauge pressure (or 105 lbs. absolute pressure) contains 1,182° above 32° or 1,182 + 32 = 1,214. Then 1,215 — 210 = 1,004°, and 1,004 × 3,400 = 3,413,600. This ÷ 1,100 = 3,075 lbs., which would have been evaporated under standard conditions with the same amount of heat, and 3,075 ÷ 30 = 102 horse-power developed.

The horse-power of boilers is best defined by the heating surface of a boiler, and is different according to their construction. A tubular boiler will give one horse-power to every 15 square feet of heating surface; a flue boiler every 12 square feet, and a cylinder boiler 10 square feet gives one horse-power. There is no standard law governing the horse-power of steam boilers, but this rule is adopted by most experts as a fair rating.

One cubic foot of water evaporated per hour = 2 nominal horse-power.

7½ pounds of coal consumed per hour will evaporate about 1 cubic foot of water = 2 horse-power.

1 square foot of grate will consume on average 12 pounds of coal per hour = 1⅗ horse-power.

Engine Horse-Power.

All calculations to find the horse-power of an engine are necessarily only approximate, as they are modified more or less by the factors or friction in the moving parts, condensation, quality of lubricants, amount of load, etc.

The unit of power is the horse-power, and was first calculated by Watt, that prince of inventors in steam enginery; and after numerous experiments, Watt estimated the power of a good, average draught horse to be that which could lift 33,000 lbs. one foot high in a

minute, 550 lbs. in one second, or 1,980,000 lbs. in an hour. Hence we have the horse-power factor, 33,000 lbs.

Rule to Find Horse-Power of an Engine.

Area of piston in inches, multiply by pressure per square inch, multiply by speed of piston in feet per minute, and that product divided by 33,000.

$$\text{H. P.} = \frac{\text{P-L-A-N}}{33{,}000}$$

P—Pounds pressure per square inch.
L—Length of stroke in feet.
A—Area of piston in square inches.
N—Number revolutions per minute.

The pressure per square inch should be the mean pressure throughout the stroke exerted on the piston, which can be found by attaching an indicator to the engine. The result will be what engineers term, indicated horse-power.

For the net effective horse-power, deduct from the above about one-quarter for friction of the working parts.

When the indicator is not used, and in the calculation the boiler pressure is substituted for the mean effective pressure, deduct from the result obtained from 40 to 60 per cent for loss by condensation and friction of steam in pipes and passages, decrease of pressure in cylinder due to expansion, back pressure of exhaust, and friction of the working parts.

For engines from 20 to 60 horse-power, an average of 50 per cent may be deducted; for smaller engines more.

The mean pressure in the cylinder when cutting off at

¼ stroke equals boiler pressure multiplied by .597
⅓ stroke equals boiler pressure multiplied by .670
⅜ stroke equals boiler pressure multiplied by .743
½ stroke equals boiler pressure multiplied by .847
⅝ stroke equals boiler pressure multiplied by .919
⅔ stroke equals boiler pressure multiplied by .937
¾ stroke equals boiler pressure multiplied by .966
⅞ stroke equals boiler pressure multiplied by .992

Number of threads to the inch of screw on American standard wrought iron, steam, gas and water pipe, from 1/8 to 10 inches.

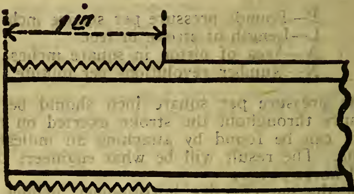


Fig. 42.

Size of pipe	1/8	1/4	3/8	1/2	3/4
Number of threads per inch	27	18	18	14	14
Size of pipe	1	1 1/4	1 1/2	2	2 1/2
Number of threads per inch	11 1/2	11 1/2	11 1/2	11 1/2	8
Size of pipe	3	3 1/2	4	4 1/2	5
Number of threads per inch	8	8	8	8	8
Size of pipe	6	7	8	9	10
Number of threads per inch	8	8	8	8	8

Difference Between Tonnage and Horse-Power. Locomotives and steamships are always rated as tonnage in figuring horse-power and tonnage; the difference is 16/35 of a horse-power equals a ton.

A square foot of uncovered pipe, filled with steam at 100 pounds pressure, will radiate and dissipate in a year the heat put into 3,716 pounds of steam by the economic combustion of 398 pounds of coal. Thus, 10 square feet of bare pipe corresponds approximately to the waste of two tons of coal per annum.

To Remove Stains From Marble.

Take two parts of soda, one of pumice and one of finely powdered chalk. Sift through a fine sieve and mix into a paste with water. Rub this composition all over the marble and the stain will be removed. Wash it with soap and water, and a beautiful bright polish will be produced.

To Clean Marble.

Mix up a quantity of the strongest soaplees and quicklime to the consistency of milk; lay it on the stone for 24 hours; clean it and it will appear as new. To further improve, rub with fine putty powder and olive oil.

To determine necessary surface in square feet for aspirating coil in ventilating flue divide air to be moved per hour by .950 for steam radiation, and .600 for water radiation.

To reduce Fahrenheit temperature to centigrade subtract 32 from Fahrenheit reading, multiply by 5 and divide by 9.

To reduce centigrade to Fahrenheit multiply centigrade reading by 9, divide by 5 and add 32.

Liquid Measure.

4	gills	make 1 pint.
2	pints	make 1 quart.
4	quarts	make 1 gallon.
31½	gallons	make 1 barrel.

Boiling Points of Various Fluids.

Water in Vacuum	98°
Water, Atmospheric Pressure	212°
Alcohol	173°
Sulphuric Acid	240°
Refined Petroleum	316°
Turpentine	315°
Sulphur	570°
Linseed Oil	597°

Melting Points of Different Metals.

Aluminum	1400°
Antimony	1150°
Bismuth	507°
Brass	1900°
Bronze	1692°
Copper	1996°
Glass	2377°
Gold (pure)	2066°
Iron (cast)	2786°
Iron (wrought)	2912°
Lead	617°
Platinum	3080°
Silver (pure)	1873°
Steel	2500°
Tin	446°
Zinc	773°

Weights and Measures.

Measure of Length.

4	inches	make	1 hand.
7.92	inches	make	1 link.
18	inches	make	1 cubit.
12	inches	make	1 foot.
6	feet	make	1 fathom.
3	feet	make	1 yard.
5½	yards	make	1 rod or pole.

Measure of Length—Continued.

40 poles make 1 furlong.
8 furlongs make 1 mile.
$69\frac{1}{6}$ miles make 1 degree.
60 geographical miles make 1 degree.

$$\left.\begin{array}{r}1760 \text{ yards}\\ 5280 \text{ feet}\end{array}\right\}1 \text{ mile.}$$

Measure of Surface.

144 square inches make 1 square foot.
9 square feet make 1 square yard.
30¼ square yards make 1 rod, perch or pole.
40 square rods make 1 square rood.
4 square roods make 1 square acre.
10 square chains make 1 square acre.
640 square acres make 1 square mile.
Gunter's chain equal to 22 yards or 100 links.
272¼ square feet make 1 square rod.
43,560 square feet make 1 acre.

Measure of Solidity.

1728 cubic inches make 1 cubic foot.
27 cubic feet make 1 cubic yard.

Firing.

Steam.

Experience teaches us that in many cases where the water leaves the boiler and goes into the radiation the trouble is caused by improper firing.

The steam gets low either from neglect or over night, and the fireman, desiring to get the steam up as soon as possible, opens the ash-pit door, and with a strong draft in chimney flue urges up the fire to an

intensity far beyond what the boiler needs, and this causes the water to boil so furiously that it lifts out of the boiler. The ash-pit door is only made to gain access to the pit to take out the ashes, and should be used for this purpose only, and not to create draft, as the draft door is made sufficiently large to admit all the air necessary for combustion. In other words, don't put a 12-horse power fire under a 4-horse power boiler.

Caution.

If the water should disappear from the gauge glass, do not draw the fire, but cover it with wet ashes, and allow the boiler to cool before refilling with water.

When connecting damper regulator, adjust the chains so that both the draft door and check draft door will be closed when the regulator lever is level, and there is no steam in the boiler. In this position chain should be tight.

Metal That Expands in Cooling.

Lead, 75; antimony, 16.7; and bismuth, 18.3.

Expansion of solids from 32° to 212°, at 32° being equal to 1.

Brass	1.00191
Common brick	1.00055
Cast iron	1.00111
Cement	1.00144
Copper	1.00175
Fire brick	1.0175
Glass	1.00085
Granite	1.00079

Water expands .1 of its bulk in freezing.

A column of water 2.3 ft. high equals 1 ℔. per sq. in. pressure.

Ordinary atmosphere will sustain 33.9 ft. of water in height.

35.84 cu. ft of water=1 ton.

39.84 cu. ft. of ice=1 ton.

1 cu. ft. of sea water=64.3 lb.

Sea water contains 4 to 5 oz. of salt per gallon.

Weights of Different Metals.

Lead	..............1 foot square, inch thick=59.06
Copper	............1 foot square, inch thick=45.3
Wrought-iron	.......1 foot square, inch thick=40.5
Cast-iron	..........1 foot square, inch thick=37.54
Cast-steel	..........1 foot square, inch thick=40.83

Under no consideration should lead be used in fittings as lead has a tendency to stop the circulation in time. A good practical man will always lead on the threads.

Pipe and Fittings.

Use ample-sized pipe. If one or two sizes large it will not be detrimental to the successful circulation of the steam or water, but if too small will in all probability cause failure. Pipes of ample size are the most satisfactory and economical in the long run. Use fittings which will allow of the free and rapid circulation of the steam or water, connecting them in such a manner as to permit proper expansion and contraction of the pipe.

Shrinkage of Castings.

Pattern-makers' rule for Cast-Iron	...1/8	of an inch longer per linear foot.
" " " " Brass	......3/16	
" " " " Lead	.......1/8	
" " " " Tin	........1/12	
" " " " Zinc	.......3/16	

PLUMBING.

Method of Wiping Joints.

Watching somebody wipe joints, a clear description of how it is done, and acquaintance with the traits and qualities of materials used, are essential, but practice in the art of wiping joints has more to do with it making one proficient than has mere practice to do with proficiency in any other line of work. One may give the closest attention to the manual operation of making a thousand joints when the cloth and ladle are in the hands of some one else and yet fail to remember the how and wherefore for the hundred movements necessary to success.

Before commencing to wipe a joint, one should be positive that the pipe is firmly set, that the cleaning is well done and of proper length, that the junction of the ends is well made, so that solder will not run through into the pipe, that the edges are well pasted or otherwise protected, so that the solder will not adhere except at the cleaning, that no undue currents of air are passing through it, that there is enough solder in the pot to get up the heat and do the work and that the cloth is in good condition.

The beginner should keep the solder hot, leaving the pot in the furnace while practicing, so that he can put back and remelt the cold solder from time to time. He can do no better than to try to imitate the motions of those who know how. Practice will soon teach him a few points which words cannot explain to the inexperienced. Let the novice take the cloth in his left hand, holding it forward, so as to cover the tips of his fingers and take a ladle of solder in his right hand, hold the cloth under the cleaning and drop the solder, drop by drop, upon the different parts where the joint is to be made. A single drop of solder too hot will melt a hole through a pipe very quickly. Keep the ladle moving, so that the drops will fall in different places. When some solder gathers on the cloth put it up on top again and drop the solder on it and continue this operation until you have got the required amount of heat on the pipe so that your solder and the pipe is of the same heat and then form and wipe your joint.

Solder is a metal or alloy used to unite adjacent metallic edges or surfaces.

It must be rather more fusible than the metal or metals to be united, and with this object the compo-

nents and their relative amounts are varied to suit the character of the work.

As the melting point of lead is 617° to 626° according to the purity of the lead, solder must melt at a lower temperature.

The solder depends very much upon the nature and quality of both tin and lead.

No definite rule can be made for the melting points of plumbers' solder, although the following table is said to be nearly correct:

3 parts lead to	1	of tin, coarse melts at	480° F.
60 parts lead to	40	of tin, plumbers melts at	440° F.
1 part lead to	1	of tin, fine melts at	370° F.
1 part lead to	1½	of tin, tin pipe melts at	330° F.

It often happens that solder will become spoiled by getting zinc or other ingredients into it, which causes the solder to harden or crystallize contrary to its nature.

This is shown by the solder quickly setting or working badly, while if disturbed when cooling it is a kind of gray blue.

This is often caused by dipping brass or copper work into the pot for tinning, and also when soldering brass or copper to lead.

If too hot the zinc leaves the copper, and the tin takes it up, because the tin and zinc readily mix. A small portion of zinc will also cause the lead and tin to separate.

If there is zinc in solder, heat it to about 900° or nearly red hot, throw in a small quantity of sulphur (brimstone), which melts at 226° F. This high temperature is needed to melt the zinc, which melts at 773° F., and being lighter than lead or tin, has a tendency to float with the help of sulphur.

The sulphur mixes with the zinc and brings up all foreign substances to the surface.

Skim the solder well and after the heat is reduced to about the melting point of solder, add resin or tallow, to free the sulphur, and the solder should be clean.

Lead and tin can be separated by one rising above the other, so always stir before taking out a ladleful for use.

Never stir solder when red hot or burnt.

If allowed to burn, the nutriment or binding qualities are gone, and the pliable property which makes the solder work like butter, deducts from the ductility always needed in good working solder.

Some solder will work well for several heats and then become coarse; its appearance will be black and dull, become very porous and unreliable without more tin.

This is due to the fact that poor tin has been employed or some foreign substance, such as antimony, has been mixed with it. It will form teats or drops on the bottom of the joint and it will be difficult to make the joint. When this occurs, clean the solder with sulphur and resin and add tin to replace the deficiency caused by cleaning.

When solder hangs to the cloth it is too fine and needs a little lead, and when it sets too quickly or too coarse add tin.

Never leave sulphur in ladle or solder pot, as it cannot be cleaned without considerable trouble.

The fluxes generally employed for soldering, are, for iron, borax or sal-ammoniac; for zinc, brass or copper, sal-ammoniac or zinc chloride; for lead or tin pipe, resin or tallow.

A liquid for use in fine solder is made by dropping small pieces of zinc into two ounces of muriatic acid, until bubbles cease to rise, then dilute by adding water.

In tinning metals, the object is to prepare the surfaces that they may readily unite with the melted solder.

The tinning operation is best performed at a moderate heat. When overheated, the coating of solder, or the tinning as it is called, is reduced to a yellow powder and is destroyed. The tinning must be restored before it can be used.

Resin is recommended as a flux for tinning copper bits which are to be used for soldering lead and for tinning all brass and copper work upon which sof solder joints are to be wiped.

Articles composed of brass or copper, such as faucets, nipples, etc., should be tinned, filing to remove the coating or oxides, leaving the metal surface clean, then coating with a flux. Solder is then applied with a bit entirely covering the filed surface.

It is bad practice to dip brass articles into a pot of molten solder which is to be used for wiping purposes, because some of the zinc, of which the brass

is partly composed, will melt out and alloy with the solder, thus spoiling it. Articles composed wholly of copper, provided they are perfectly clean and free from filings, will do no injury to the solder.

Iron articles may be tinned by thoroughly cleaning the surfaces and treating them with sal-ammoniac before applying the solder.

Great care must be taken, when filing brass or other metals preparatory to tinning them, that the filings do not fall on the bench or such places that solder falling from wiped joints will pick them up. As a precaution, filing should not be done near the place where the wiping is to be done.

Solder flows better at high temperatures, provided the temperature is not so high as to oxidize it.

Solder will flow into a joint until it is chilled, therefore, it flows farthest when it possesses a large excess of heat above that which is necessary to maintain it in the fluid condition.

The heat necessary for making wiped joints is supplied wholly by the molten solder, thus, it is essential that the solder should possess a considerable surplus of heat. The temperature is limited, however, by the tendency of the solder to oxidize.

The strength of a joint not only depends upon the quantity, but the quality of the solder.

Too long manipulation spoils the solder and weakens the lead, the first joint made, if the metals are thoroughly fused, will be the most reliable, even if the shape is not perfect.

In making wiped joints, the metals to be joined should be heated to a temperature nearly equal to the fusing point of the solder.

Care should be taken that they are not heated beyond this temperature.

Fit ends of pipe tightly to prevent solder entering the interior, thoroughly clean all surfaces to be wiped, and immediately cover this cleaned surface with grease or oily matter, to prevent tarnishing.

In shaving, do not dig out the lead, as it is weakened and the joint cracks at the edges much sooner than it otherwise would.

It is of great importance that all wiped joints should be sound and reliable.

Patient practice until one can make a perfect joint is necessary. No wiped joint is perfect unless strong in body, perfectly fused, clean at the edges, true in form and free from solder inside.

In all joints the solder should be well mixed, and so fuse with the pipe that the metals will be perfectly united.

Wiped joints, properly made, are the strongest known to the trade, and generally recognized in the plumbing industry as one method of proving a plumber's status.

What is a metal?

An elementary mineral substance possessing considerable specific gravity, hardness and cohesion and requiring a high degree of heat to liquefy.

Give the symbol, ore and composition of the metals of interest to plumbers.

Lead
Tin
Zinc
Copper
Iron
Pb
Sn
Zn
Cu
Fe
Galena
Tinstone
Blende
Glance
Pyrites Iron
Magnetite
Hematite Iron and Oxygen
Lead and Sulphur
Tin and Oxygen
Zinc and Sulphur
Copper and Sulphur
Copper and Sulphur

Give the relative tenacity of the above metals.

Lead	1	or lowest.
Tin	1 1-3	times that of lead.
Zinc	2	times that of lead.
Copper	18	times that of lead.
Iron	27½	times that of lead.

Give the relative malleability of the five metals.

Copper, tin, lead, zinc and iron?

What does tenacity denote?

The relative power of resistance the metals have, to being torn apart.

On what does the malleability of a metal depend?

A great deal on its tenacity, coupled with softness.

What is the melting point of iron and some of its properties?

Melts at 2786° F., is very ductile and malleable and appears in three forms, malleable, or wrought, in its purest state, or cast, when containing carbon in different proportions.

At what temperature will zinc melt and what are its peculiarities?

Melts at 773° F., is somewhat brittle and fairly permanent in air. It is a protecting coating for iron under the name of galvanized iron, and dissolves easily in acids.

What are the peculiarities of tin and its melting point?

Melts at 428°, is a brilliant white metal in the pure state and produces a peculiar crackling noise when bent, called the "cry" of tin. It is very malleable, but also slightly ductile.

What is copper, its melting point and some of its uses?

An elementary metallic substance of a pale, red color, moderately hard, malleable and ductile. Copper fuses at 1742° F. It is the most useful of all the metals for alloy. Mixed with tin it forms bronze: with zinc it forms brass; is a good conductor of heat and electricity and one of the most useful of metals.

What is brass, its uses and melting point?

It is composed of copper and zinc of different proportions and has no certain temperature for fusing, as the component parts vary; about 1100° F. It is

one of the most useful of alloys, more fusible than copper and not so apt to tarnish. It is malleable when cold, but not so when heated.

Describe the properties of lead, its melting point and some of its uses?

Lead is of a bluish gray color, very soft and of slight tenacity. Its proper name is galena or sulphide of lead. It melts at 612° to 617° F., according to its purity. It is used in the arts and sciences, and combines with other metals in various alloys.

What are alloys and some of their properties?

An alloy is a combination by fusion of two or more metals. All alloys are opaque, have a metallic luster, are more or less ductile, elastic and malleable, also good conductors of heat and electricity.

What is solder, and of what is plumbers' solder composed?

A metal or alloy to unite adjacent metallic edges or surfaces and is composed of lead and tin in different proportions.

What are the proportions of lead and tin in plumbers' solders, and their melting points?

Coarse mixture	3 lead	1	tin, melts 480°
Plumbers' mixture	60 lead	40	tin, melts 440°
Fine mixture	1 lead	1	tin, melts 370°
Tin pipe mixture..........	1 lead	1½	tin, melts 330°

What spoils solder and how should it be cleaned?

Allowing zinc or antimony to mix with it and by burning it.

Clean it by heating the solder to 900° or more, introducing sulphur, which helps impurities to rise. When this is skimmed, put in resin, and the mixture should be purified. This high temperature is needed to melt antimony which fuses at 834°, and zinc at 773°.

Why should solder never be allowed to burn?

Because the pliable property and nutriment are extracted.

What are some of the fluxes used in soldering different metals?

For iron, borax or sal-ammoniac. For zinc, copper or brass,—sal-ammoniac or zinc chloride. For lead or tin pipes,—tallow or resin. Also, for iron and zinc, drop small pieces of zinc into two ounces of muriatic acid until bubbles cease to rise; then add a little water.

Sewage.

Sewage is composed of waste water carrying in suspension organic and inorganic wastes. The organic wastes contain both animal and vegetable matter, such as urine and excreta and wastes from kitchen sinks, slaughtering, rendering and packing establishments, etc. Inorganic wastes are from manufacturing establishments, as for instance paper mills, foundries, gasworks and tar or asphalt plants. The decomposition of the organic wastes produces menthane or marsh gas according to the best authorities. This is a poisonous gas, but not so virulent as carbon-monoxide, which is a deadly poison, producing almost instant death.

Carbon monoxide and carbon dioxide gases are probably produced in sewage by inorganic wastes. Invariably it will be found that the presence of such gases in public sewers carrying sewage is due to leaks in gas mains.

All brick sewers are porous, nearly all tile sewers leak at points where connections have been made and thereby absorb the leaking gas from mains. Such gases are poisonous and cause many of the fatal accidents which sometimes happen in sewer manholes, catch basins and excavations. These gases must be kept out of houses for the same reason, hence we have traps, vents, etc., in our modern plumbing systems.

The treatment of raw sewage by means of septic tanks and filter beds, or by dilution, renders it harmless.

The action of animalculæ in septic tanks is being studied by engineers and chemists to the end that sanitary disposal of sewage may be accomplished in a manner suitable to inland towns.

The dilution method of disposal is more suitable to towns and cities on tide water or on large rivers, provided the volume of water in the rivers is sufficient and other towns do not use such water for domestic purposes.

Ventilation of Sewer.

Sewers and drains, together with plumbing systems, are ventilated in order to carry off the gases mentioned and to protect the inhabitants of buildings from gas poison and infection.

Sewers are ventilated by manholes in the street, having perforated iron covers.

Drains are ventilated in the same manner and by the vent pipes in a plumbing system.

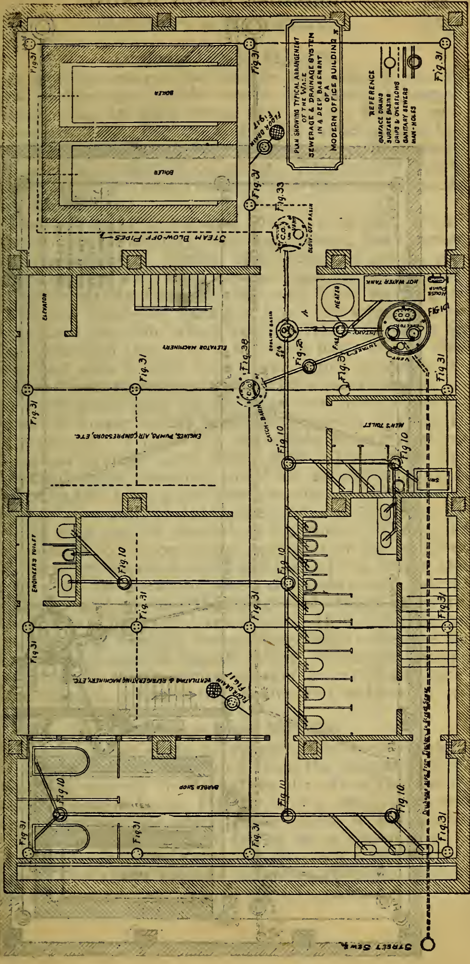
Plumbing systems are ventilated by the extension of soil and waste pipes through the roof of a building. Vent pipes are connected into these soil and waste pipes above the highest waste connection, or extended separately through the roof.

Vent pipes are designed to safeguard trap seals and provide for a circulation of air in the plumbing system.

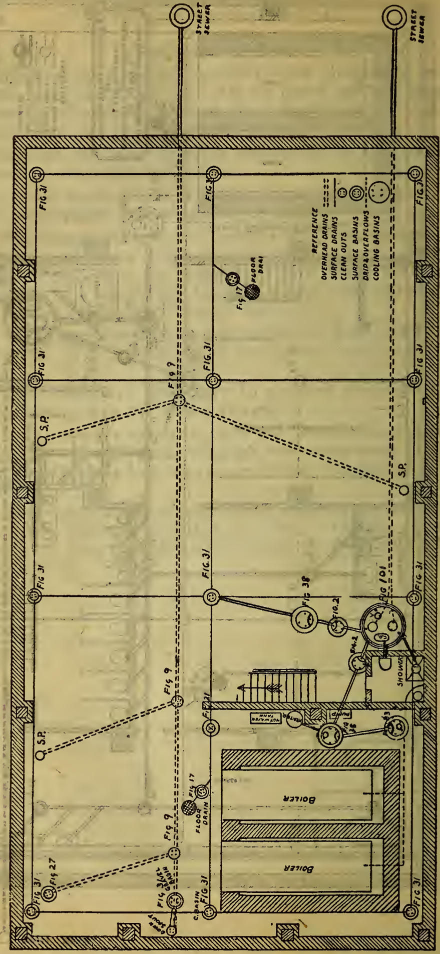
Trap seals are necessary to prevent the entrance of sewer gas to the living rooms.

If there were no vent pipes the accumulated gases would eventually pass through the water seal, or the latter would be lost by reason of air compression or vacuum.

The installation of plumbing appears to be very simple. There is a reason for simple things. Ignorance of that reason may produce very serious consequences.



Drainage System—No. 102



Drainage System—No. 103

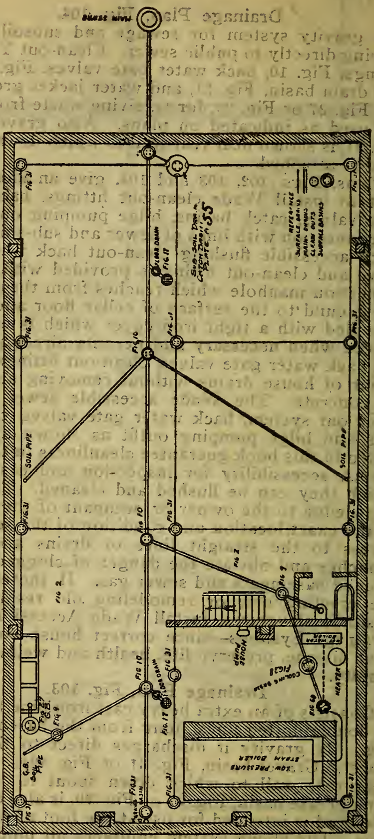
Drainage Plan, Fig. 104.

A gravity system for sewage and subsoil waters flowing directly to public sewer. Clean-out Y branch fittings, Fig. 10, back water gate valves, Fig. 2, subsoil drain basin, Fig. 31, and water jacket grease basin, Fig. 27 or Fig. 29, for receiving waste from sinks are used as indicated on plans. Also gravel basin, Fig. 31, is shown near rear wall to which down spouts may be attached.

Plans, Figs. 102, 103 and 104, give an idea where best to install Wade clean-out fittings, back water gate valves, catch basins, bilge pumping outfit, etc. In connection with lines of sewer and sub-soil drains. Each accessible flushing clean-out back water gate valve and clean-out fitting is provided with an iron inspection manhole which reaches from the sewer in the ground to the surface of cellar floor and is also provided with a tight iron cover which is easily removed when necessary and permits direct access to the back water gate valves, clean-out fittings and interior of house drains without removing any floors or concrete. The Wade accessible sewer flushing clean-out system, back water gate valves, catch basins and bilge pumping outfit as shown and illustrated in this book guarantee cleanliness in the house drains, accessibility for inspection and easiness by which they can be flushed and cleaned. They give knowledge to the owner or occupant of the building of the exact location and condition of the sewer and access to the straight lines of drains and lateral branches and obviate the danger of clogged sewers, flooded basements and sewer gas. If, therefore, you are erecting new or remodeling old residences or business structures, install Wade Accessible House Drainage Systems—since correct house drains prevent disease, preserve life, **health** and **welfare** of **humanity.**

Drainage Plan, Fig. 103.

Consists of an extra heavy cast iron pipe, as shown in double dotted lines, hung from the basement ceiling. By gravity it discharges direct to the public sewer. Gravel basin, Fig. 31 or Fig. 49½, is shown near rear wall to which down spout is connected. Sink grease basin, Fig. 27 or Fig. 29, is also shown on plan and is intended for use at the foot of sink waste pipe. The above system embraces all pipes leading from fixtures located above the basement.



Drainage System No. 104

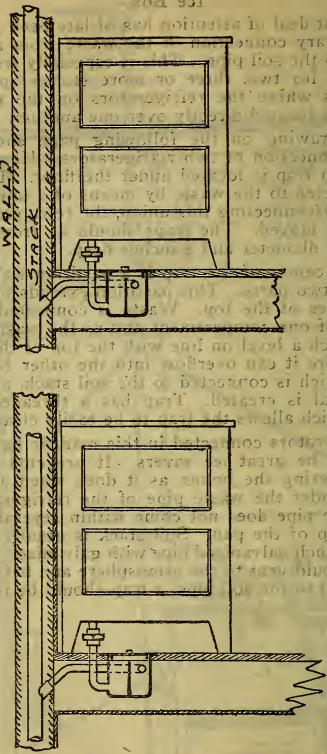
Ice Box.

A great deal of attention has of late been given to the sanitary connection of the waste from a refrigerator to the soil pipe. This is especially true when planning for two, three or more stories apartment buildings where the refrigerators on the different floors are located directly over one another.

The drawing on the following page shows the latest connection of two refrigerators. Here a special drum trap is located under the floor. The trap is connected to the waste by means of a union. By simply disconnecting this union, the refrigerator can easily be moved. The traps should be from 6 to 8 inches in diameter and 8 inches deep.

In the center of the trap is a partition wall dividing it in two parts. This partition extends to within two inches of the top. Waste is connected to the bottom of one compartment and as the waste water must reach a level on line with the top of the partition before it can overflow into the other compartment, which is connected to the soil stack, a perfect water seal is created. Trap has a threaded brass cover which allows the trap to be easily cleaned.

Refrigerators connected in this manner have been found to be great ice savers. It prevents hot air from entering the boxes, as it does when a pan is placed under the waste pipe of the refrigerator, as the waste pipe does not come within several inches of the top of the pan. Soil stack is usually of two or three-inch galvanized pipe with galvanized fittings. Stack should vent to the atmosphere and before it is connected to the soil pipe, a trap should be inserted.

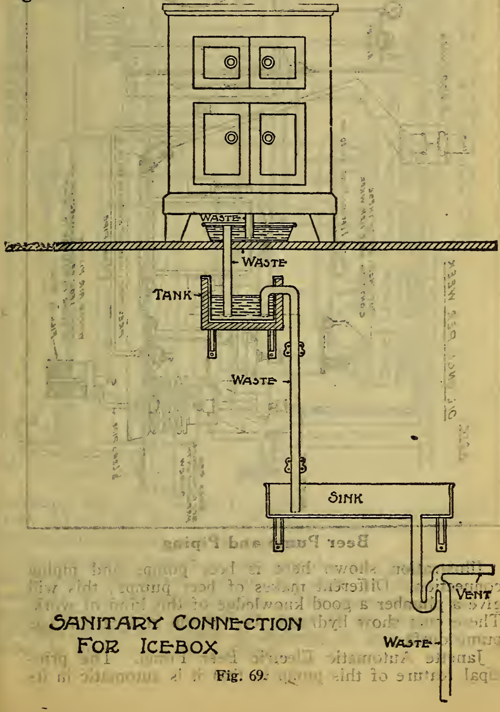


SANITARY CONNECTION OF REFRIGERATORS TO SOIL STACK.

Proper Way of Draining an Ice Box.

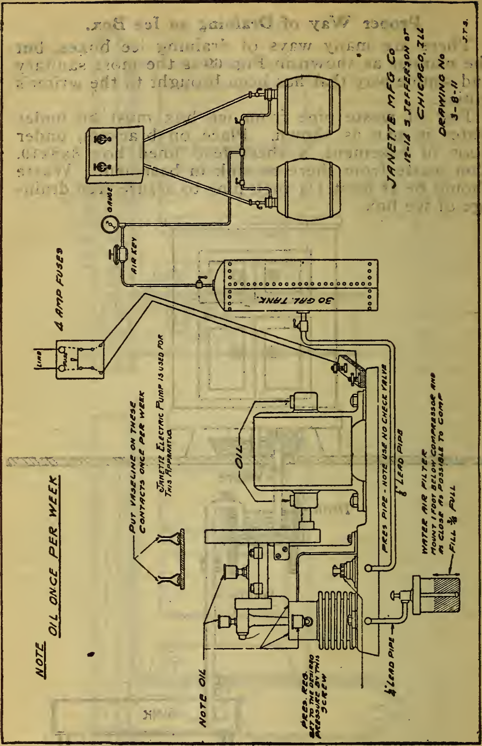
There are many ways of draining ice boxes, but the manner as shown in Fig. 69 is the most sanitary and simple way that has been brought to the writer's notice.

End of waste pipe from ice box must be under water in pan as shown. Place on brackets, under floor of basement, a sheet lead lined box 8x8x10. Run waste from there to sink in basement. Waste should be at least 1¼ inch pipe to assure free drainage of ice box.



SANITARY CONNECTION FOR ICE-BOX

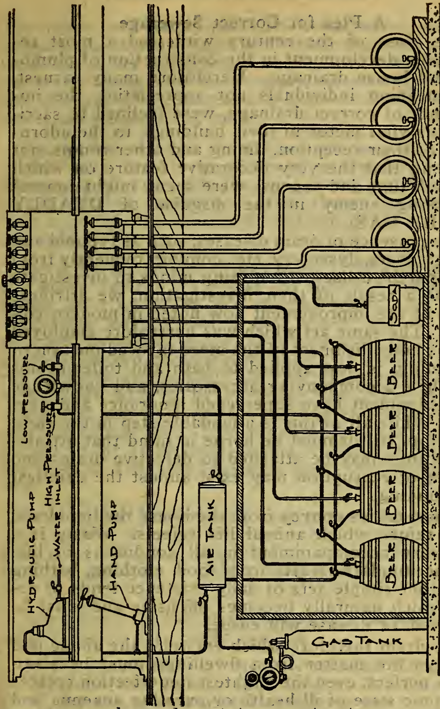
Fig. 69.



Beer Pump and Piping

Illustration shown here is beer pumps and piping connection. Different makes of beer pumps; this will give a plumber a good knowledge of this kind of work. These cuts show hydraulic beer pump and carbon gas pump outfits.

Janette Automatic Electric Beer Pump. The principal feature of this pump is, that it is automatic in its



Combination Gas and Water Outfit Showing Pumps and Piping

operating and can be set to operate at any pressure from 10 to 50 pounds, and when connected to a storage tank the air can be regulated.

The automatic cut-off is very simple, with the positive knock out never failing to start or stop the pump at the pressure desired. The connections as shown here are very simple to make if the sketch is followed outright. There is nothing to get out of order in the Janette Beer Pump.

A Plea for Correct Sewerage.

The close of the century witnessed a most remarkable development in the construction of plumbing and house drainage. Heretofore many earnest, well-meaning individuals not appreciating the importance of correct drainage, were inclined to sacrifice this vital factor in their buildings, to the adornment of their reception, dining and other rooms, not realizing that the very decorative feature on which so much time and expense were spent, might conceal a lurking enemy in the disguise of DEADLY SEWER GAS.

The presence of drain diseases, such as typhoid and scarlet fevers, dysentery, etc., coming frequently from no apparent cause led inquiring minds to investigate and as a result of their investigation, we attribute much of the improvement now noted in modern edifices. The same art which was heretofore employed for the embellishment of the more favored portion of a dwelling is now applied to bath and toilet rooms and their accompanying accessories, and knowledge and refinement have superseded ignorance and neglect. While all of this is a laudable step in the right direction, still it must be borne in mind that attractive fixtures may be attached to defective drains and a state of corruption may exist amidst the daintiest surroundings.

House drains convey from the house the liquid and solid refuse which animal life rejects. Waste is a necessary accompaniment in all conditions of life. The accumulated waste from food, clothing, bathing and other simple acts of daily existence tends to decay, which naturally becomes offensive and must be removed, or disease will ensue.

The drain therefore which encircles the abode and conveys the matter from dwellings must be absolutely perfect, even the slightest imperfection creates a chronic state of ill health or puzzling anaemia and oftentimes death. Every builder should weigh these facts well, he should familiarize himself with the drainage system of his house and adopt only that which is convincingly trustworthy in every respect.

There is another danger which must not be overlooked. Many families having closed up their homes during a period of travel, perceive on their return an offensive odor permeating the different apartments.

The difficulty is simply this—The water which stands in the traps of house pipes and which shuts off gases from the sewer when wash basins, etc., are in use, not receiving its customary supply, evaporates during the absence of occupants, and gases from the main sewer are permitted to enter.

For weeks, perhaps, there has been no water seal in the traps, the ascent of sewer air has been continuous, so that not only the air is utterly unfit to live in but curtains, carpets and other absorbing furnishings have become saturated with the pollution thus acquired.

Let it be remembered, that when lavatories, sinks and other fixtures are not in use they are gradually losing by evaporation the trapped water seal, and authorities have declared that sewer gas or sulphurated hydrogen is the most poisonous of all the gases of known composition, that it is heavier than the ordinary atmospheric air, that experiments have been made with it by chemical authorities which show that one part of the gas and two of the air will kill animal life. This gas therefore must be removed so far away from us that it cannot return in the form of dangerous invisible gases of decomposition.

It must then be obvious to any person that a thorough system of house drainage and plumbing is necessary in order that the building may be kept free from the pollution in public sewer and its poisonous air.

The remedy for this evil is not so very far away but what it can be very easily reached.

At the proceedings of the International Congress of Hygiene and Demography held at Washington, D. C., by the most eminent architects and sanitary engineers in the world, the most important subject discussed was the sanitation of the interiors of houses connected with the public sewers, and it was unanimously adopted that the end and object of the systematic drainage of a house is to endow it with a good system of water supply and discharge for waste water and to regularly flush the interior of the drains by clean pressure water, it being

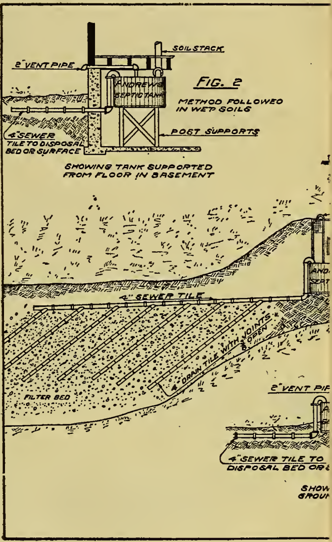
Resolved, that the object will be the most certainly attained where the following essential rules are strictly observed: To exclude from the interior of our houses all sewer gas, to avoid pollution of the soil by fecal matter or waste water, to prevent the generation of deleterious gases in the soil and in the air below and around our houses, to discharge as rapidly as possible into the public sewer all fecal matter and waste matter produced.

The application of these essential rules necessitates an intercepting flushing, FRESH AIR INLET TRAP IN THE HOUSE DRAIN, inside main wall of cellar for THE EXCLUSION FROM THE HOUSE OF POLLUTIONS, AND SEWER GAS IN THE PUBLIC SEWERS, a proper system of ventilation, pipes that are air tight and water tight, the employment of proper materials for the pipes, proper dimensions and thicknesses for all pipes, FLUSHING AND CLEANSING JUNCTIONS WITH VERY OBTUSE ANGLES, proper construction of water closets, baths and other sanitary appliances, FACILITY OF ACCESS TO ALL HOUSE DRAIN PIPES FOR FLUSHING, INSPECTION AND TESTING THEM, sufficient CLEAN-OUT CONNECTIONS, periodical visitation and cleansing when necessary.

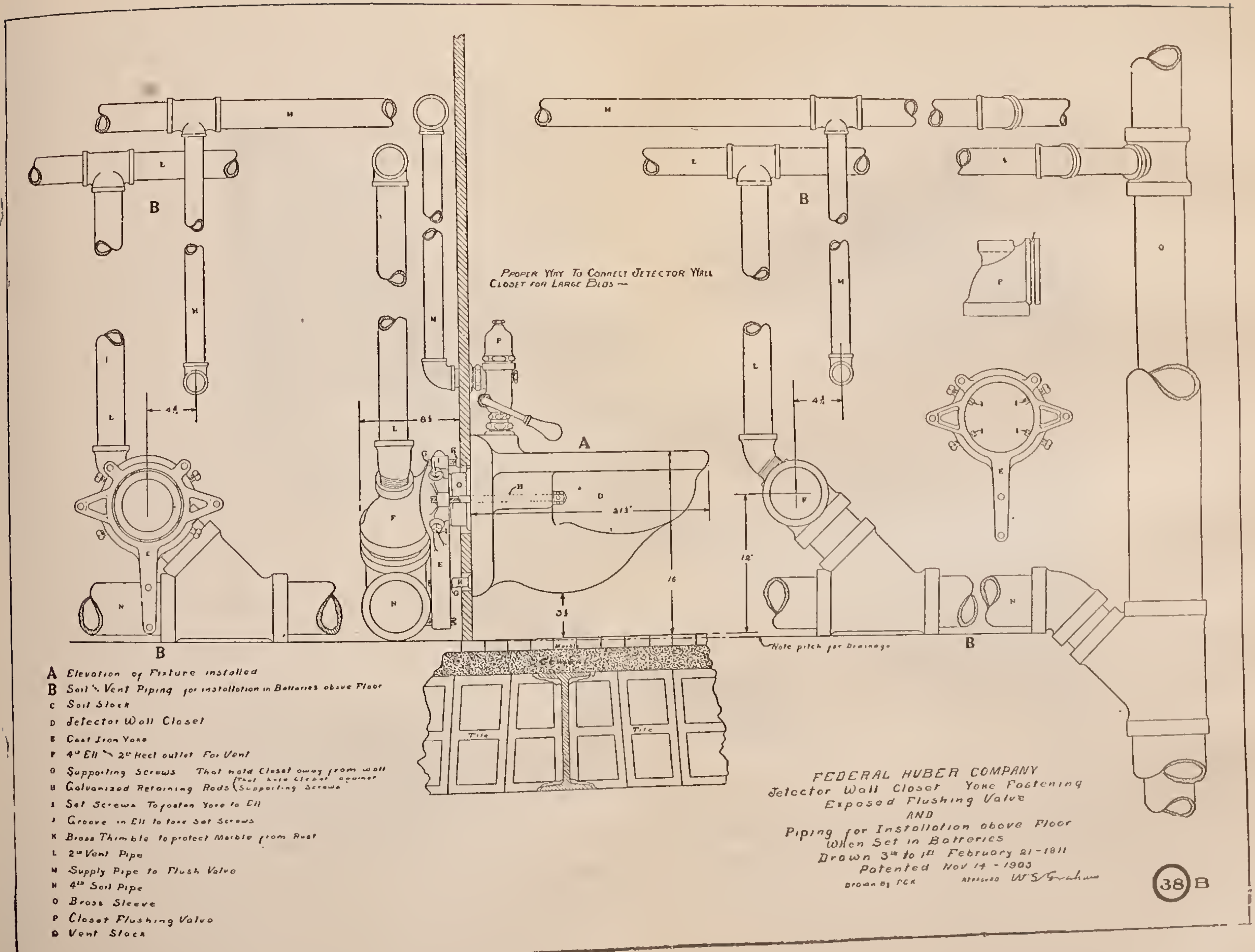
Every city, town or village in the United States has a plumbing ordinance of their own, and each thinks they have the best.

The plumbing that is shown in this book is the latest and best that can be done, and the illustrations can be followed **successfully.**

We show crown venting, also continual venting.



Sewage Dispo


Proper Way To Connect Jetector Wall Closet for Large Blds —
A
B
B
B
B
A Elevation of Fixture installed
B Soil & Vent Piping for installation in Batteries above Floor
C Soil Stack
D Jetector Wall Closet
E Cast Iron Yoke
F 4" Ell & 2" Heel outlet For Vent
G Supporting Screws That hold Closet away from wall
H Galvanized Retaining Rods (That hold Closet against Supporting Screws
I Set Screws To fasten Yoke to Ell
J Groove in Ell to take Set Screws
K Brass Thimble to protect Marble from Rust
L 2" Vent Pipe
M Supply Pipe to Flush Valve
N 4" Soil Pipe
O Brass Sleeve
P Closet Flushing Valve
Q Vent Stack
Note pitch for Drainage
FEDERAL HUBER COMPANY
Jetector Wall Closet Yoke Fastening
Exposed Flushing Valve
AND
Piping for Installation above Floor
When Set in Batteries
Drawn 3" to 1' February 21-1911
Patented Nov 14 - 1905
Drawn by FGK
Approved W S Graham
38 B

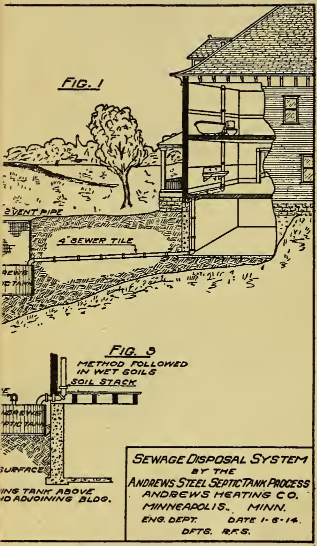


FIG. 1
2 VENT PIPE
4" SEWER TILE
REWS
TIC TANK
FIG. 3
METHOD FOLLOWED
IN WET SOILS
SOIL STACK
NDREWS
PTIC TANK
SURFACE
ING TANK ABOVE
ID ADJOINING BLDG.
SEWAGE DISPOSAL SYSTEM
BY THE
ANDREWS STEEL SEPTIC TANK PROCESS
ANDREWS HEATING CO.
MINNEAPOLIS., MINN.
ENG. DEPT. DATE 1-6-14.
DFTS. R.F.S.

sal System.

This installation shows one of the latest sanitary installations, as used in one of the large public buildings.

We start from the main stack 5" and then branch both ways to 4" with 45° Ys, and nipple into a 45° ell and then raise with the nipple to 90° closet ell, which is grooved and has a 2" top vent opening. The closet cast iron yoke is then attached to this grooved ell by chilled steel bolts which rest into the groove.

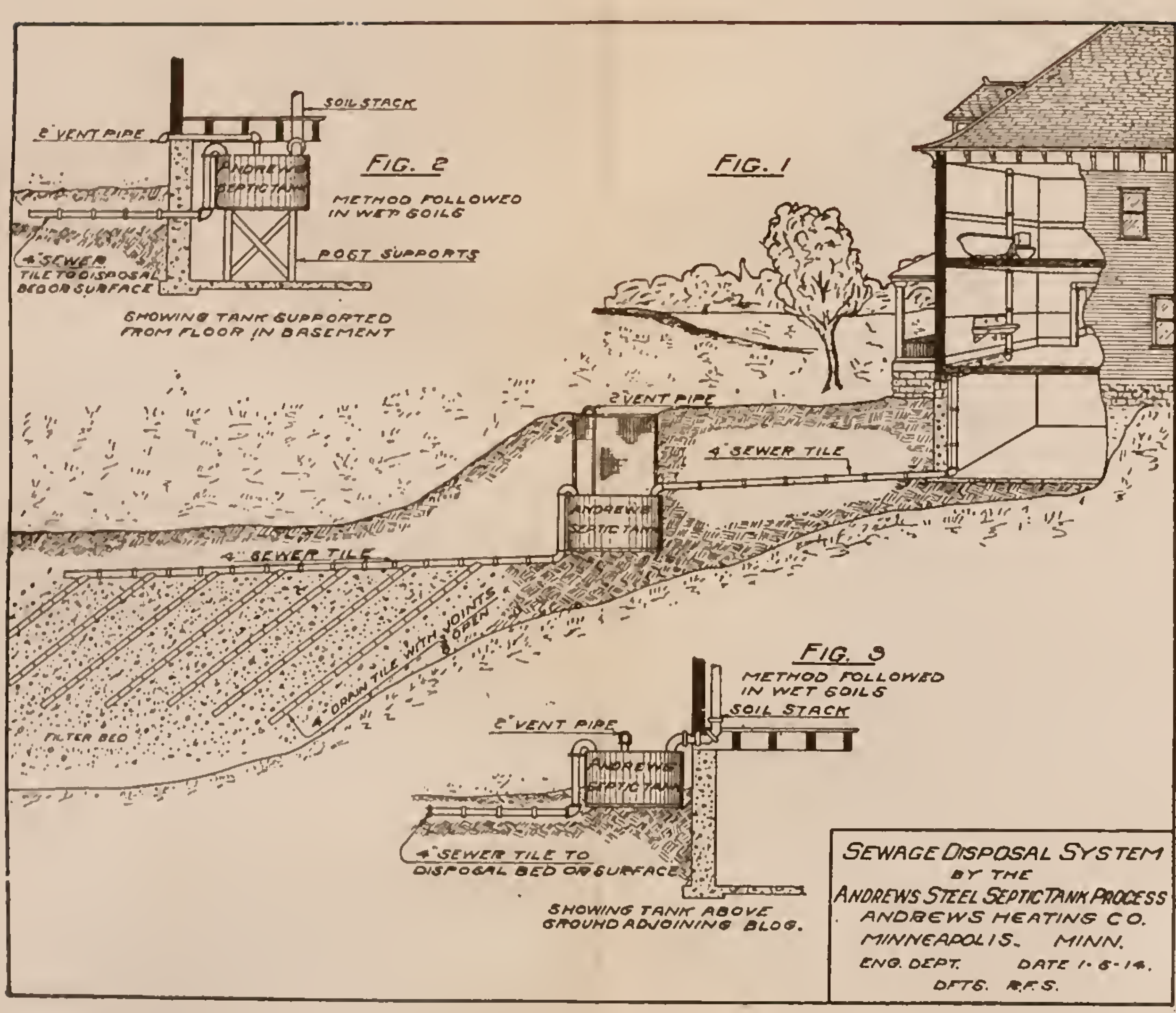
Into this grooved ell is then screwed a brass iron pipe threaded wall flange with a bell recess for gasket. The closet is then fastened to the yoke by two long holding bolts. The recessed horn of the closet slips into the gasket and brass wall flange. The closet does not receive any support from the wall at all. The three stud bolts, two on the top and one on the bottom, having hole cut out through wall and being screwed from the yoke and rest against the back of the wall, making it thereby, absolutely impossible to break the marble or wall at any time.

The vent is taken from the stack of 4" and branches both ways as a tee and with 2" drops into the top of the 4x2x4 grooved closet ell. The supplies are taken from the main riser of a three-inch into heads of 2½", where they drop down to 1¼" into an elbow into the stop of the closet valve.

This is based on a battery of twenty closets, as the size of batteries increase or diminish, the supply is reduced in proportion. On the soil waste this size is reduced according to the size of the number of closets in the battery.

This is one of the new installations for wall closets and also is adapted to wall urinals. The construction being so that the closet can be removed by just unfastening of the two holding bolts. On account of its construction of the two studs on the top and the one on the bottom, the breaking strength has never been fully determined, although tests have been made up to 1700 lbs. actual weight.

Another test being made, which is more severe on closets of this description, is not to see how much dead weight the closet will stand, but to see what conditions the joints are in, after subjecting the closet to a test of jumping on same.



Sewage Disposal System.

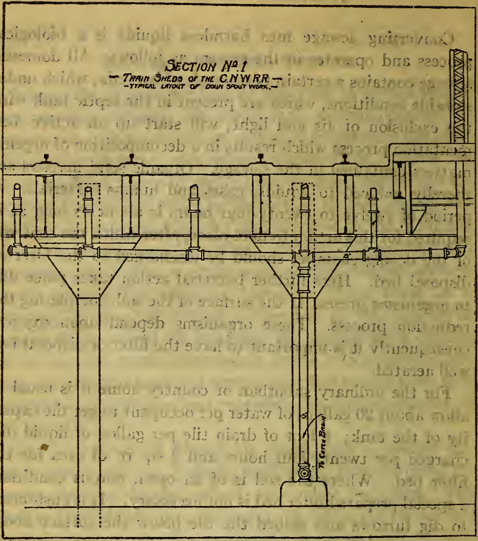
Sewage Disposal System

Among the various methods of disposing of sewage wastes in a sanitary manner, the septic tank system operated in conjunction with a sub-surface system of irrigation is the most easily adapted for a wide range of conditions. There are many modified forms of septic tank systems, which operate more or less satisfactorily in proportion to how closely the designer has followed the principles involved in the reduction of sewage wastes by this process. Present day practice and experience show that a septic tank sewage disposal system should possess the following features. There must be a reservoir or tank of suitable proportion to the number of persons to be served for retaining the sewage for a definite period, an automatic discharging device which empties the tank at definite intervals of time, a filter bed or irrigation field of suitable proportions and materials for final treatment of the liquids.

The accompanying illustration shows such a sewage disposal system with an Andrews steel septic tank designed for use in dwelling houses, school and public buildings. The tank is divided into two compartments called the intake and dosing chambers and is constructed of boiler plate ¼ inch thick, has riveted heads, hand-holes, automatic siphon, intake fitting and is made absolutely air tight. The location of the tank is shown for three different conditions, the one most frequently used being shown in Figure 1. Where the ground is level and there is no basement to drain, the locations shown in Figures 2 and 3 are desirable. As shown in Figure 1 ordinary 4-inch glazed sewer tile is laid with cemented joints, having a pitch of 1 inch in 20 feet between the house and the tank and from the tank to the disposal or filter bed. At the disposal bed ordinary Y branches are used with 4-inch porous drain tile laid with ⅜ inch open joints for branches. Pieces of tile should be laid above and underneath the joints so as to prevent dirt from getting into the branch pipes. These drain tiles are laid with a pitch of 1 inch in 25 feet.

Converting sewage into harmless liquids is a biological process and operates in the system as follows: All domestic sewage contains a certain percentage of bacteria, which under suitable conditions, which are present in the septic tank with the exclusion of air and light, will start up an active fermentation process which results in a decomposition of organic matters contained in the sewage. Organic solid matters are thereby reduced to liquids, gases and humus materials. A period of twelve to twenty-four hours is about as long as is required for this action to take place, after which the contents of the dosing chamber should be discharged to the filter or disposal bed. Here further bacterial action takes place due to organisms present at the surface of the soil, completing the reduction process. These organisms depend upon oxygen, consequently it is important to have the filter or disposal bed well aerated.

For the ordinary suburban or country home it is usual to allow about 20 gallons of water per occupant to get the capacity of the tank; 1 foot of drain tile per gallon of liquid discharged per twenty-four hours and 3 sq. ft. of area for the filter bed. Where the soil is of an open, porous condition, a special prepared filter bed is not necessary. It is customary to dig furrows and embed the tile below the surface about 12 inches. Where the ground is of an impervious nature, it is necessary to dig trenches 4 feet or 5 feet deep and 24 inches wide and fill in with gravel, sand or cinders to within 1 foot of the surface and embed the tile.



Drainage of New Depot

Drinking fountains are supplied with filtered water and cooled by an ice machine and pumped through a circulating system.

The fountains are distributed through the station, beneath the train shed and to the power house, covering a distance of four city blocks.

It requires 63 9-inch drain pipe connections to city mains to drain the entire plant. Four 4-inch water mains are provided.

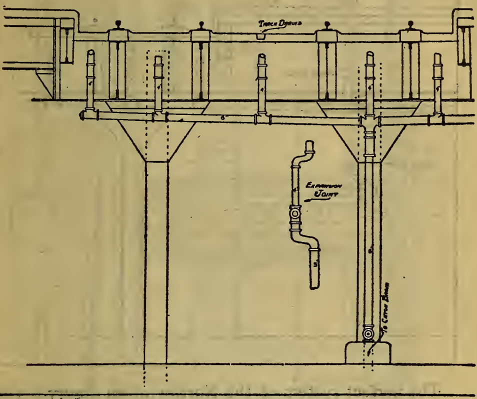
A series of cast iron settling basins are placed in the underground sewers which serves the down spouts and track drains. They are placed about 75 feet apart, one emptying into another. In this manner all the cinders and track rubbish is collected.

Women emigrants have a special arrangement providing a laundry equipped with 12 porcelain wash trays and a steam dryer, so that while waiting for trains, laundry work can be done.

There are also porcelain bath tubs for the use of the patrons of the C. & N. W. R. R. Co.

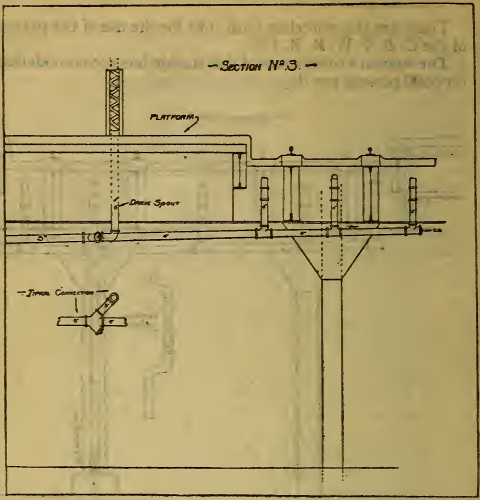
The women's toilet room of this station has accommodations for 3500 persons per day.

— SECTION Nº 2 —



Sections 1, 2 and 3 that are shown in this book are something out of the ordinary. Typical layout shows down spouts and its workings of the Chicago & North-Western train sheds. These sheds are the largest in the world, being 1200 feet long. There are 304 trains every 24 hours, in and out. Every one of these locomotives has to blow off steam, more or less. You will notice here in Section 2 that there is used in this work expansion joints made out of pipe. These expansion joints take care of expansion and contraction in case the down spouts get hot, as they naturally will, from high pressure steam from the locomotives.

This plumbing work was done by Hulbert & Dearsey, Chicago, Ill.

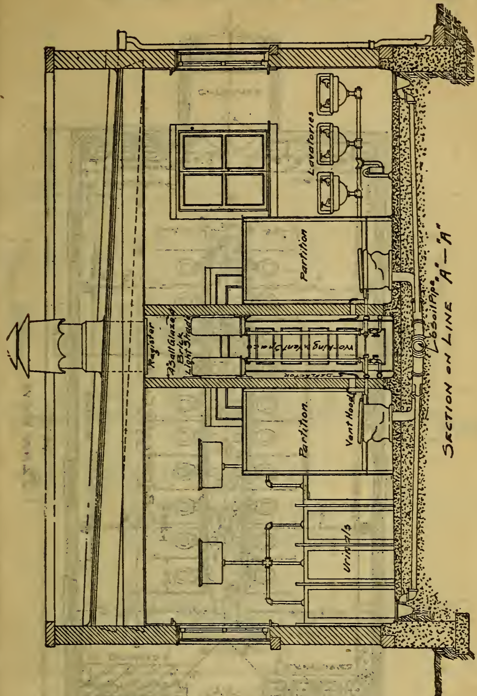


The perfect system of the Northwestern deserves your patronage.

Plumbing Railroad Station

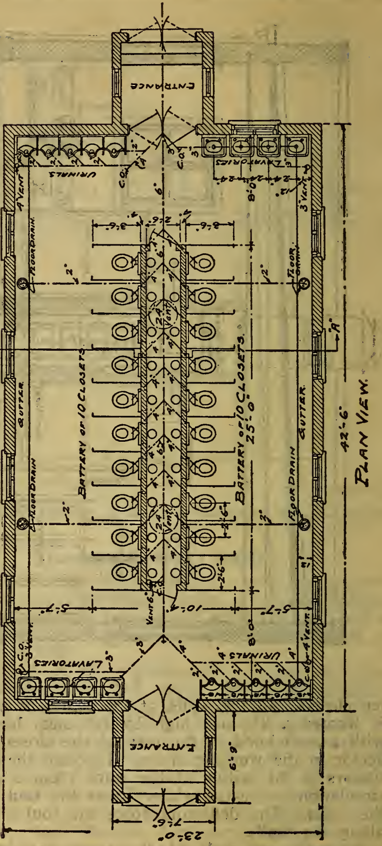
Of late years special attention has been given to the sanitary equipment of toilet rooms in railroad stations, public buildings and factories of all kinds, and public comfort stations are established at different parts of all our large cities.

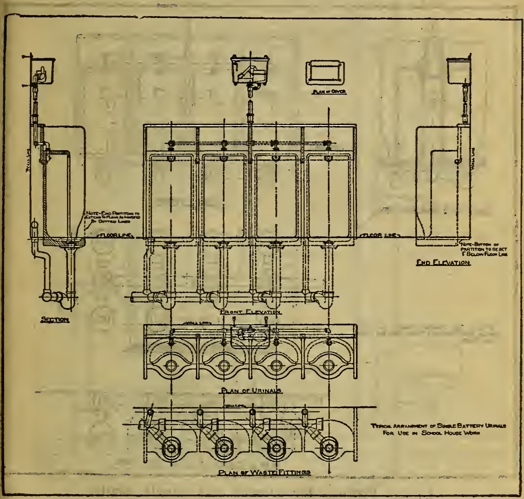
All fixtures in these places are of the latest and most sanitary kind. Soil pipes, inside of buildings, are all extra strong C. I. soil pipe. Figures 1 and 2 show a plan view and cross section, respectively, of an up-to-date arrangement of the different fixtures in toilet rooms of this kind. Here a 2′ 6″ wide working and vent space is arranged. Walls for this working space are 4 inches thick of a light colored salt glazed brick. In the ceiling of this working space are located two 24-inch diameter ventilators. On either side of these walls are, in this case, a battery of



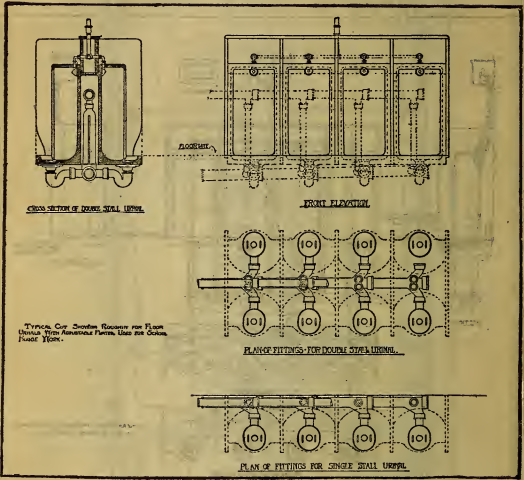
ten closets. In the walls, at the center of each closet, is located a 2¼-inch high by 16½-inch long opening with a vent hood in the rear of the closet and a deflector in the working space. Through the large ventilators in the ceiling of the work room a draught or circulation is created which draws the foul air out of the stalls. The deflectors force the foul air upwards along the walls.

At each end wall of the room are located five urinals and four lavatories. Lavatories are supplied with hot and cold water. Automatic closets and urinals should always be used.

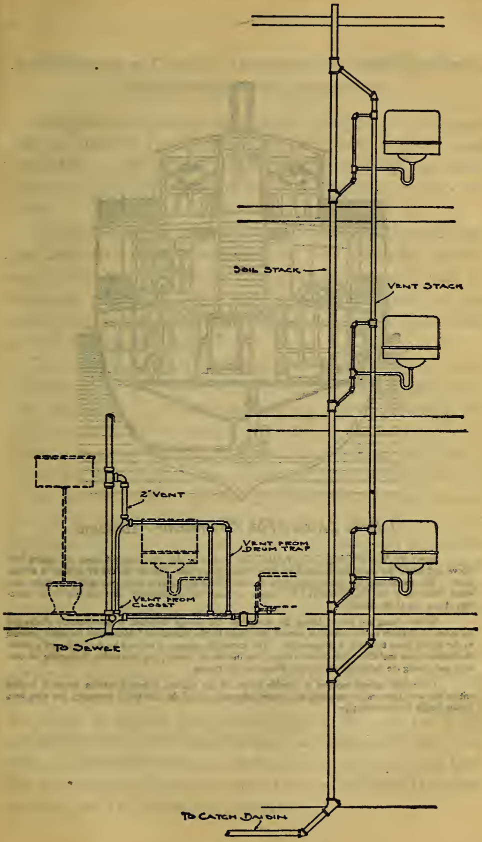

ENTRANCE
URINALS
LAVATORIES
FLOOR DRAIN
GUTTER
BATTERY OF 10 CLOSETS
BATTERY OF 10 CLOSETS 25'-0"
42'-6"
23'-0"
7'-6"
6'-9"
8'-0"
PLAN VIEW.



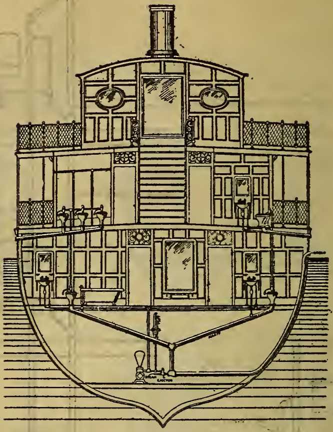
Arrangement of Single Battery Urinals



Urinal Fittings for Double and Single Stalls



Typical Vent Connections



TYPICAL LAYOUT FOR STEAMSHIP PLUMBING.

Shows the WATROUS "AQUAMETER" system in ship plumbing. Closets are shown both above and below the water line supplied by direct pump connection, without the use of storage or sewage tanks. The pump used for this purpose is of the usual form employed to maintain a uniform pressure, and when connected to the "AQUAMETER" system as shown will automatically start and stop by the operation of any one of the closets.

Where closets are placed below the water line, the sewage therefrom is automatically discharged by means of a steam ejector, which is opened and closed by the increase and decrease of the water pressure in the supply pipes to which it is connected. The instant the pressure is reduced by the flushing of a closet, the ejector opens and allows the steam to escape into the 4-inch waste pipe, effectually discharging its contents and closing the instant the water stops flowing to the closets.

To provide against accident or possible failure of the ejector, a second starting means is located within the vent pipe and is arranged to operate independently of the first when the water has risen to a certain height in the waste pipe.

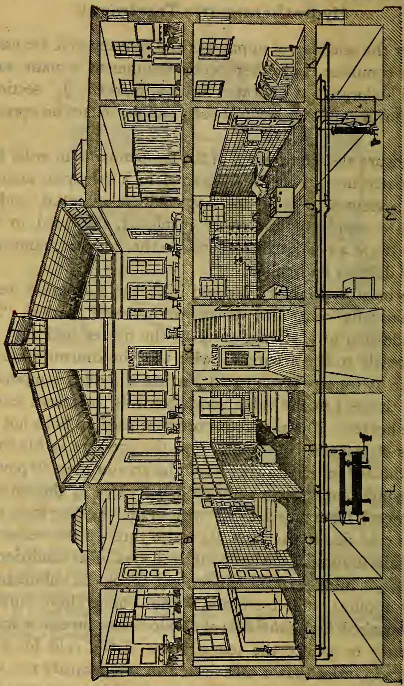
Installation of Control Apparatus for Administering Hydrotherapeutic Treatment

After the selection of apparatus and fixtures that are essential for complete Hydrotherapeutic Equipment is made, same should be located as indicated in room marked "J," sectional view showing interior medical bath establishment, on opposite page.

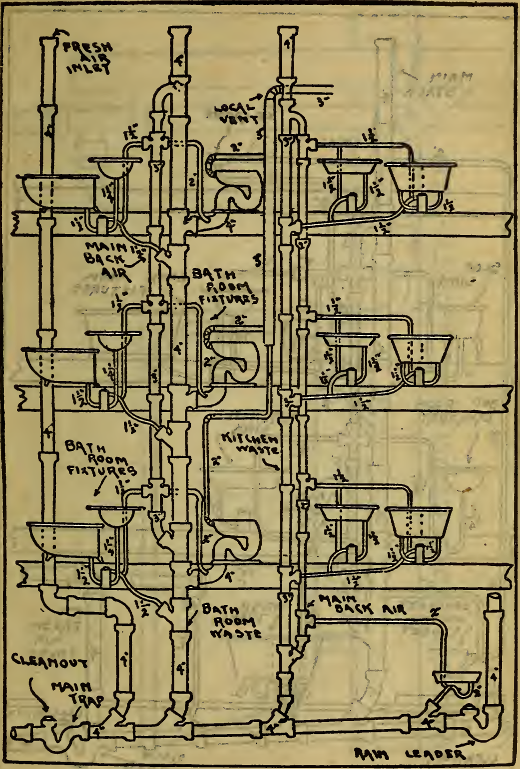
To insure absolute control of the temperatures in order that the treatment may be administered in a scientific manner, equal pressures or both hot and cold are essential, and an adequate supply of hot water furnished, delivered to this apparatus at a regulated temperature that may be maintained at 140 degrees Fahrenheit.

The most satisfactory method is to use a separate heater automatically controlled as shown in room marked "M." The addition of a storage tank to the heater indicated will add greatly to the accuracy; with this the control table will operate at times when a small particle is lodged temporarily under the seat of the valve which controls the steam leading to the heater. The maximum pressure used on both hot and cold is 40 pounds. Assuming that the pressure in the building indicated in the drawing would be greater than 40 pounds, the installation of a pressure reducing valve in the corridor, underneath room marked "K" with branch leading from same on the cold side to the apparatus, also through the heater and out again to furnish the hot water will give ideal conditions.

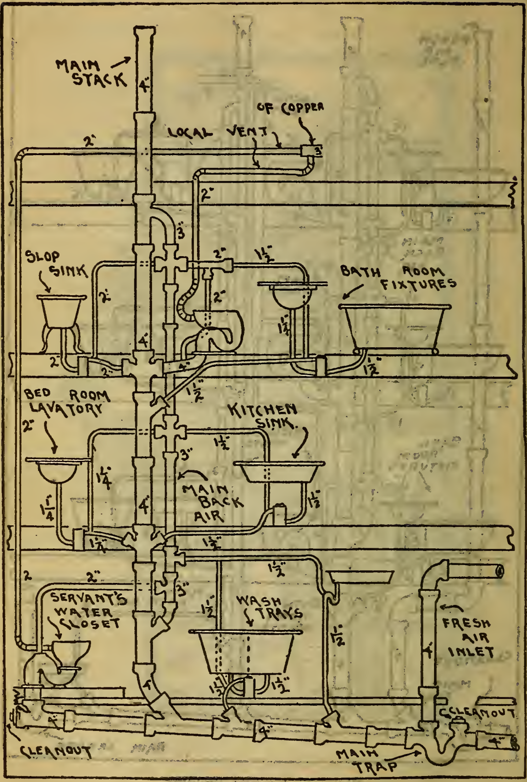
It is not intended that the patient should be submitted to direct application of ice water. The cooling chest shown in room marked "M" should be of ample size to furnish sufficient ice water to reduce the temperature of the cold for a few seconds in order that a cold dash at a temperature not lower than 54 degrees be given. The supply of hot and cold leading to the control apparatus should not be less than 1½ inches for hot, and 1½ inches for cold water.



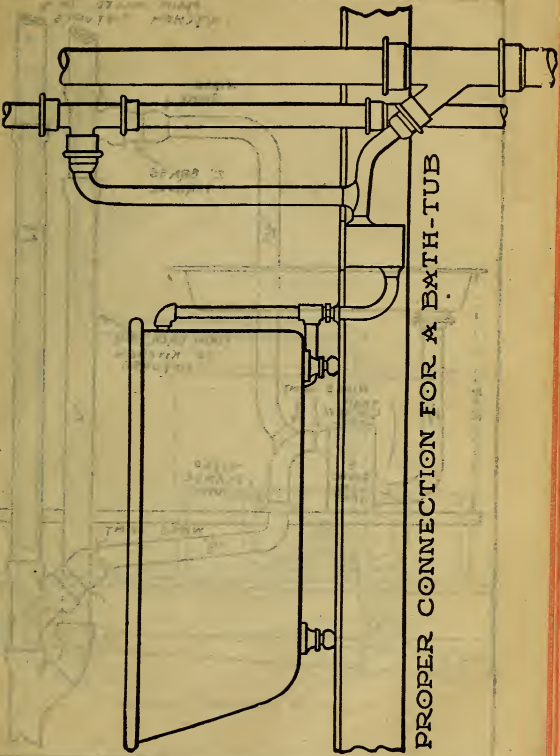
Installation of Control of Apparatus for Administering Hydrotherapeutic Treatment.
By J. L. Mott Iron Works, New York



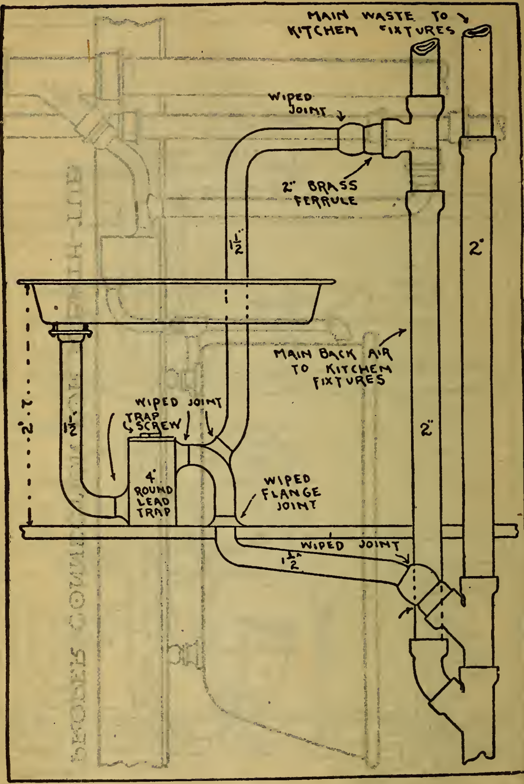
Plumbing for Flat Building



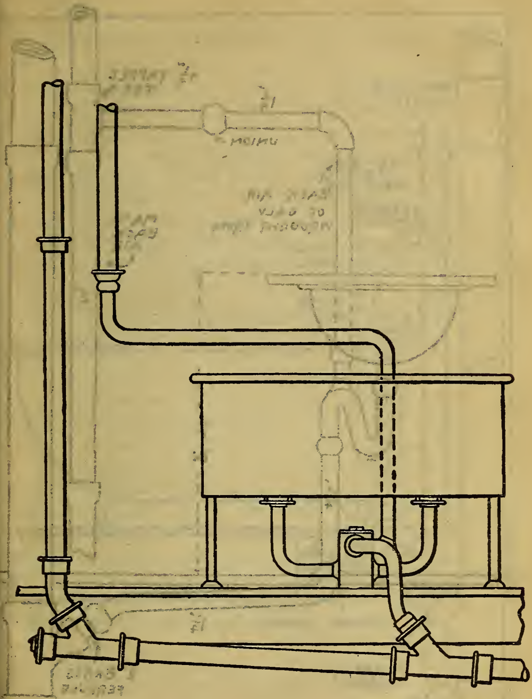
Plumbing for Residence



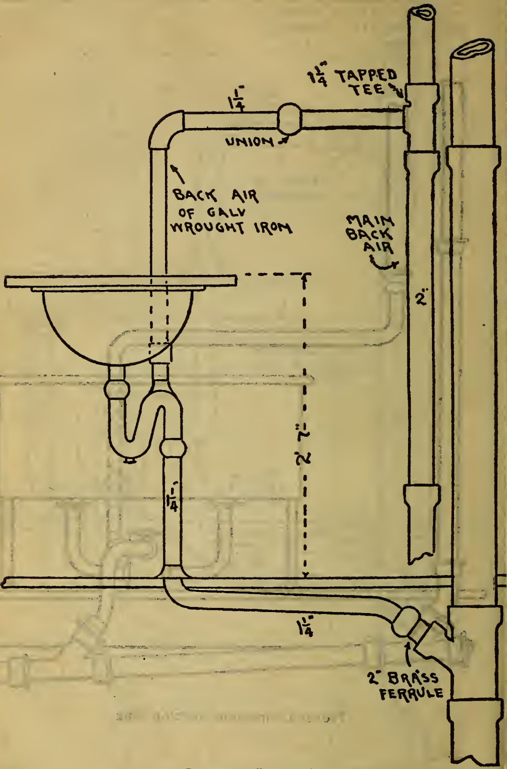
PROPER CONNECTION FOR A BATH-TUB



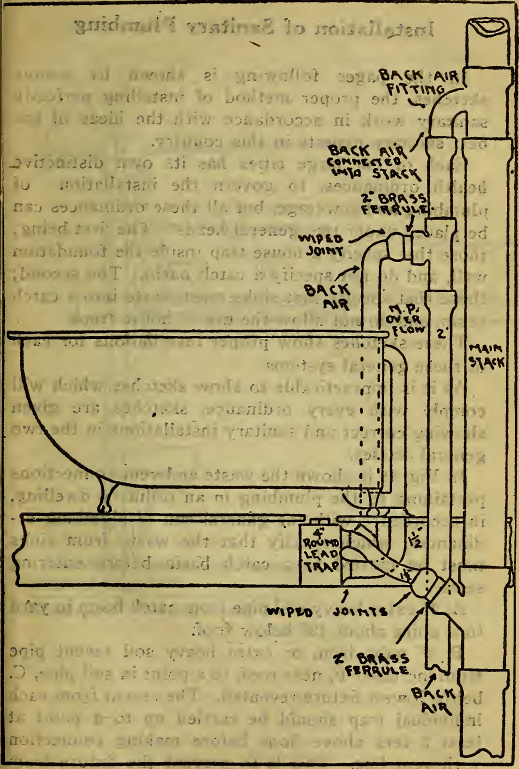
Proper Connection for Kitchen Sink



Proper Connection for Slop Sink



Lavatory Connection



Bath Tub Connection

Installation of Sanitary Plumbing

In the pages following is shown by simple sketches, the proper method of installing perfectly sanitary work in accordance with the ideas of the best sanitary experts in this country.

Each of our large cities has its own distinctive health ordinances, to govern the installation of plumbing and sewerage, but all these ordinances can be placed under two general heads: The first being; those that specify a house trap inside the foundation wall, and do not specify a catch basin. The second; those that specify that sinks must waste into a catch basin, and do not allow the use of house traps.

These sketches show proper installations for each of these general systems.

As it is impracticable to show sketches which will comply with every ordinance, sketches are given showing correct and sanitary installations in the two general classes.

In Fig. 43 is shown the waste and vent connections pertaining to the plumbing in an ordinary dwelling, in accordance with the general run of plumbing ordinances, which specify that the waste from sinks must be carried to a catch basin before entering sewer.

A. 2" extra heavy soil pipe from catch basin in yard to a point about 12" below roof.

B. 2" galv. iron, or extra heavy soil revent pipe from increaser F. near roof, to a point in soil pipe, C. below lowest fixture revented. The revent from each individual trap should be carried up to a point at least 3 feet above floor before making connection with vent line. This is to prevent the fixture from wasting through the vent pipe, in case of stoppage in waste or soil pipe. In some cities the ordinances

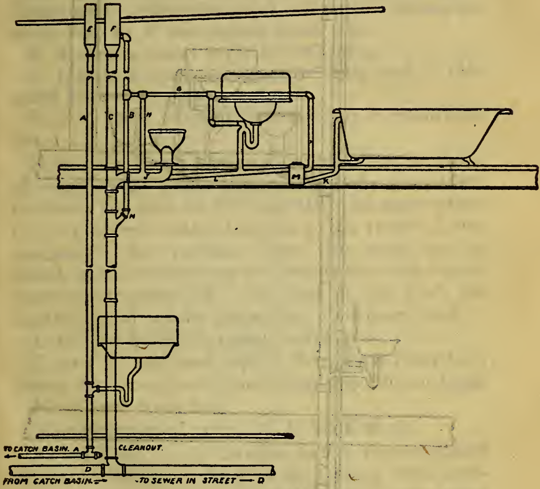

E
F
A
C
B
H
G
J
L
M
K
N
TO CATCH BASIN. A
CLEANOUT.
D
FROM CATCH BASIN.
TO SEWER IN STREET — D

Fig. 43

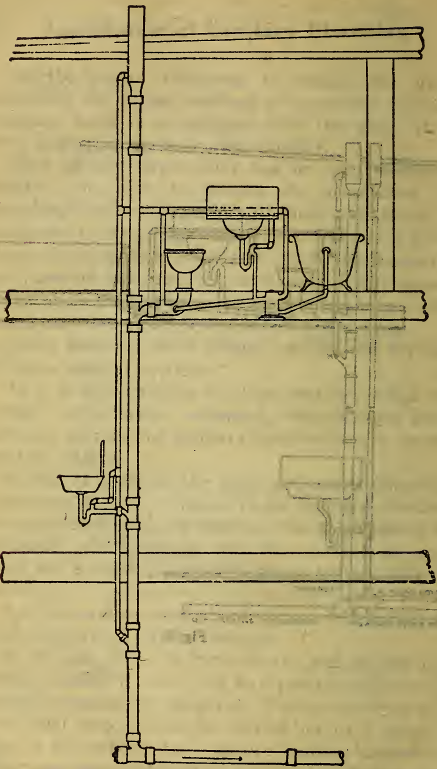


Fig. 44.

allow the connection of revent "B" to stack "C" at any point above the highest fixture wasting into stack.

C.4" extra heavy soil pipe stack, from sewer in basement to a point about 12" below roof.

D. House sewer of 4" extra heavy soil pipe from catch basin to a point about 10 feet outside of foundation wall. From this point to sewer in street, the sewer may be 6" salt glazed sewer pipe.

E. 2x4 extra heavy increaser 30" long.

F. 4x5 extra heavy increaser 30" long with 2" side outlet for revent pipe.

G. 1½" galv. revent pipe to lavatory trap and bath trap.

H. 2" galv. revent pipe to 4" lead bend or to crown of closet trap. Some cities compel the use of extra heavy soil pipe for "G" and "H." In cases where but one fixture wastes into stack, the revent is unnecessary. For instance, note that sink trap in sketch is not revented as the sink is the only fixture wasting into stack "A." In cases of this kind, the fixture should not be more than 5 ft. from stack.

J. 4" lead bend for closet waste.

K. and L. 1½" lead pipe, 3 lbs. per ft from bath tub to drum trap, and from drum trap to lead bend.

M. 4" lead drum trap.

N. connection of revent to 4" main stack.

Fig. 44 is practically the same as Fig. 43, except that it shows the work done in accordance with ordinances which do not compel the use of the catch basin.

In Fig 45 is shown the correct method of installing the plumbing in a flat building in cases where catch basins are used. The descriptions are same as given for Fig. 43 and this sketch will apply equally well to flat buildings of three and four stories. For buildings of a greater height than four stories it is only necessary to increase the size of the sewer

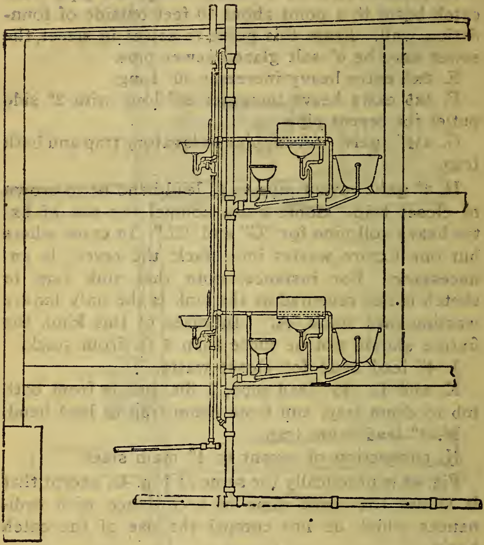


Fig. 45.

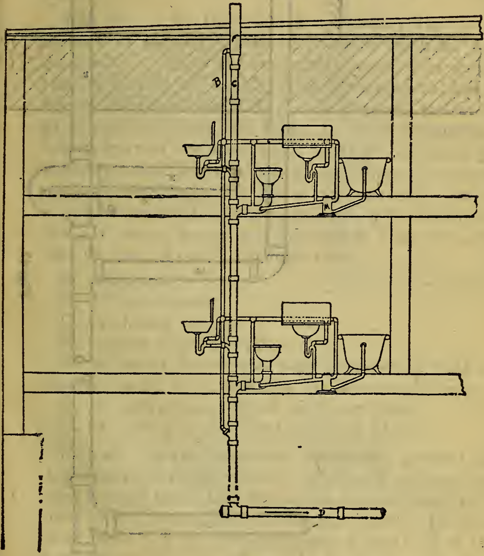


Fig. 4h

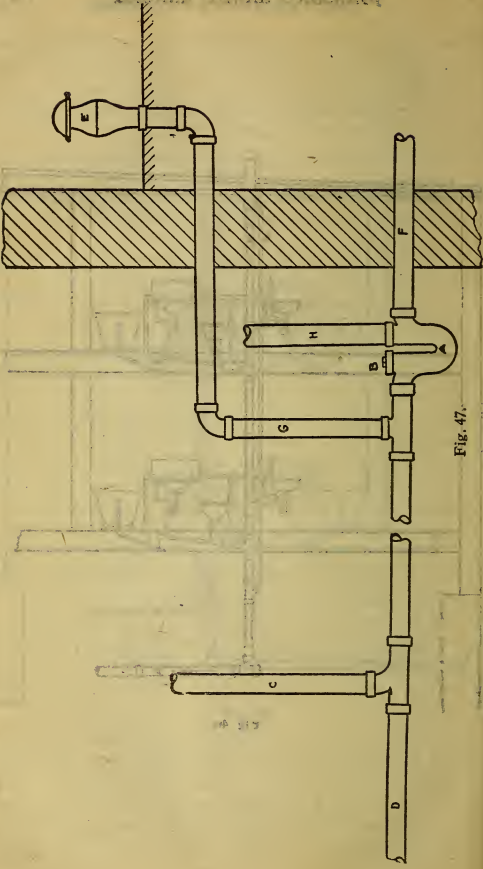


Fig. 47.

"D," the main stack, "C," the sink stack "A" and the revent stack "B."

Fig. 46 is practically the same as Fig. 45, except that it shows the work done in accordance with ordinances which do not compel the use of the catch basin.

Fig. 47. In this sketch is shown the proper method of placing a house trap with fresh air inlet. As fresh air inlets are frequently more of a menace than a benefit to health, it is advisable to use the Ayres inlet, as this fitting will prevent the escape of sewer gas from the fresh air inlet in case of a down draft in the soil pipe. As the house trap prevents the ventilation of the street sewer through the roofs of dwellings, the sewer gas naturally escapes at the street level. To obviate this, it is advisable to run a 4″ extra heavy soil pipe stack from the street side of trap, directly through roof.

B. Cleanout.
C. 4″ main stack.
D. 4″ house sewer.
E. Ayres fresh air inlet.
F. 4″ extra heavy soil pipe, connecting with salt glazed sewer, 10 ft. outside of foundation wall.
G. 4″ extra heavy fresh air inlet pipe.
H. 4″ extra heavy vent through roof.

Fig. 48. In this figure is shown the general construction of the catch basin. It should be made with hard burned brick laid in cement with a stone or cement cover, and a removable iron cover. It should be at least 3 ft. in diameter, have a depth of at least 3 ft. below the water line, and carried up to grade. The trap should be built of brick, or can be made by using a quart r bend turned down from the sewer pipe. The inlets from the sink and from the down spouts should be at least 6″ above the water line. Catch basins should be placed not nearer than 10 ft. from the foundation wall, and the water level in the catch basin should be below the line of the

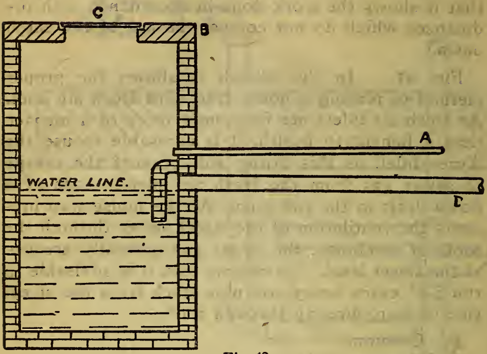


Fig. 48.

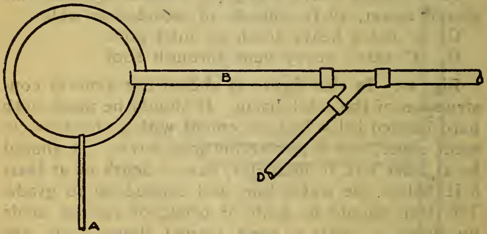


Fig. 49.

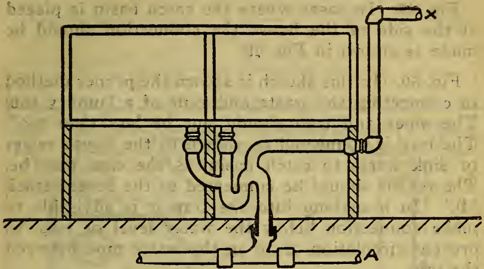


Fig. 50.

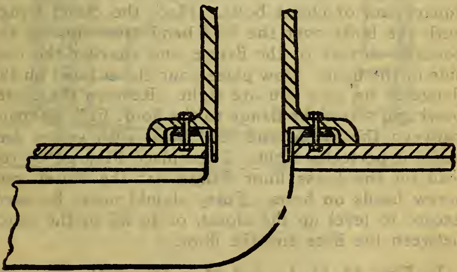


Fig. 51.

basement floor. In the sketch, "A" represents the sink waste, "B" the stone cover, "C" the removable iron cover, and "D" the house sewer.

Fig. 49. In cases where the catch basin is placed at the side of the house the connection should be made as shown in Fig. 49.

Fig. 50. In this sketch is shown the proper method of connecting the waste and vent of a laundry tub. The pipes and trap should not be less than 1½". The trap is connected as shown to the house sewer or sink waste to catch basin, as the case may be. The revent should be connected to the revent stack "B." In branching into the trap it is advisable to make connection below the water level of trap, to prevent circulation of air in the waste pipe between the tubs.

Fig. 51. In this sketch is shown a simple and sanitary method of setting a closet. The lead bend should be cut off on a level with the top of brass floor flange. Cut out the floor to allow for the square end of closet bolts. Place the closet flange with the bolts over the lead bend after tinning the concave surface of the flange, and shaving the outside of the bend. Now place your closet bowl on the flange to be sure you are right. Remove the closet bowl and screw the flange to the floor. Fill the space between the flange and lead bend with solder and make it perfectly tight. Then place litharge or red lead on the brass floor flange, set the closet, and screw heads on bolts. Putty should never be used, except to level up the closet, or to fill in the space between the base and the floor.

In Figs. 52, 53, 54, and 55 is shown the plan and piping for a factory, school or public toilet room. Fig. 52 shows the floor plan of the toilet room. Fig. 53 is a cross section showing the waste and vent piping for the closets and urinals. Fig. 54 shows the waste and vent piping for the wash and slop sinks.

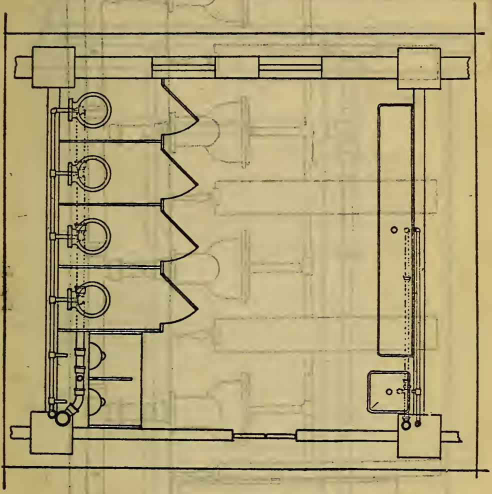


Fig. 52.

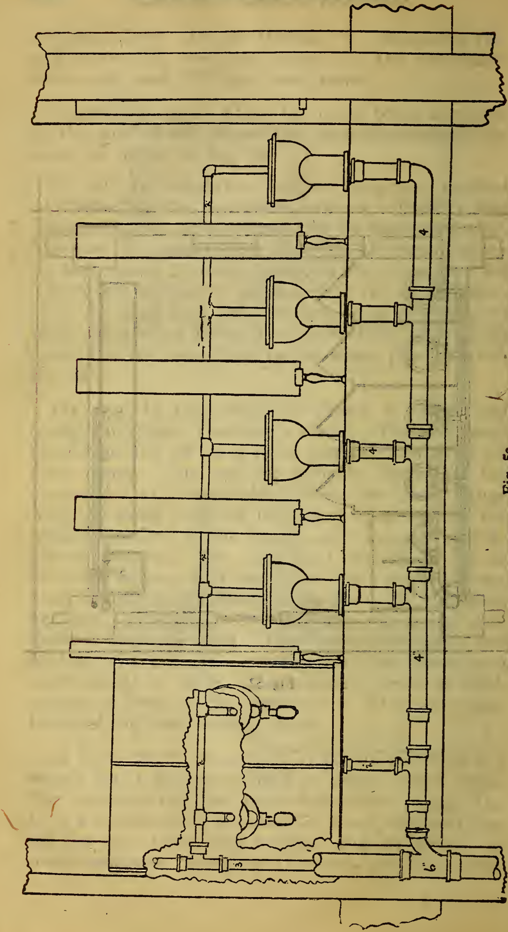


Fig. 53.

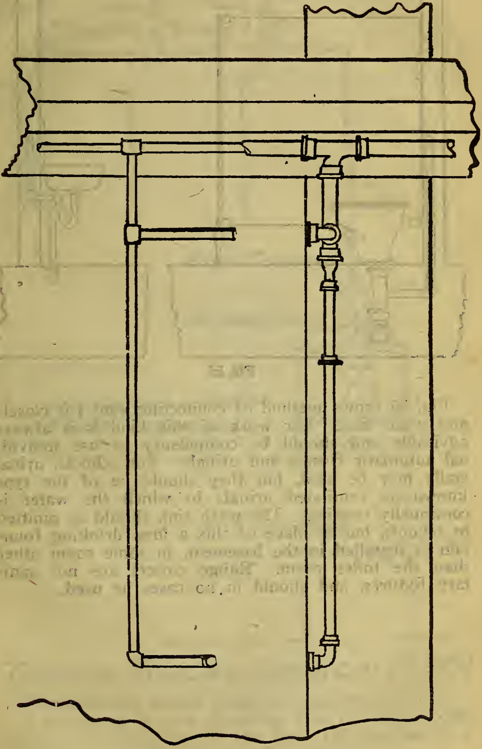


Fig. 54.

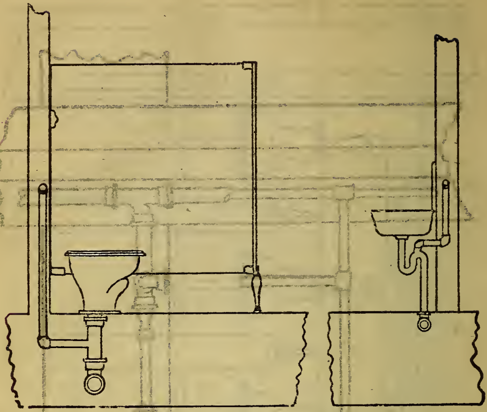
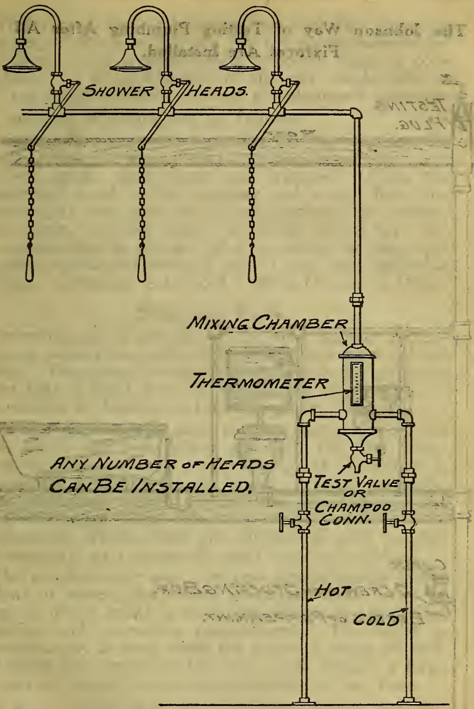


Fig. 55.

Fig. 55 shows method of connecting vent for closets and wash sink. For work of this kind it is always advisable and should be compulsory to use individual automatic closets and urinals. For schools, urinal stalls may be used, but they should be of the type known as ventilated urinals in which the water is continually running. The wash sink should be omitted in schools, but in place of this a long drinking fountain is installed in the basement, in some room other than the toilet room. Range closets are not sanitary fixtures, and should in no cases be used.



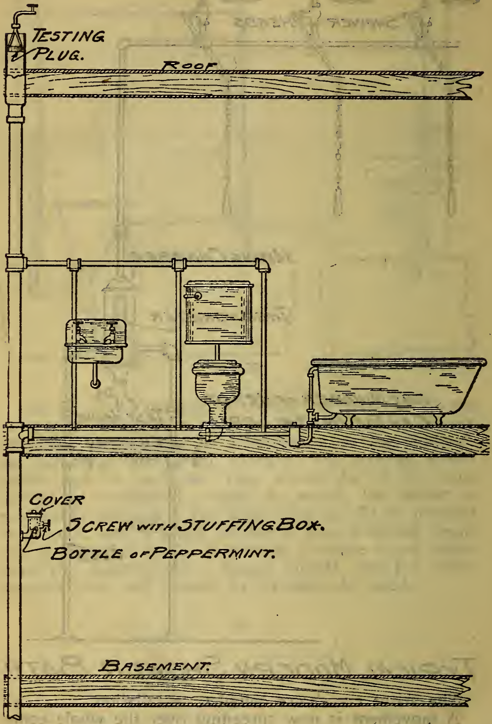
TYPICAL MODERN SHOWER BATH

The above cut shows complete installation.

A movement is now spreading over the whole country for the abolition of the bath tub because it is considered unsanitary.

The only satisfactory arrangement for the bath is the modern sanitary shower.

The Johnson Way of Testing Plumbing After All Fixtures Are Installed.



Full Instructions on Following Page

This test is the most severe test that the plumbing can get, as there is no way for the peppermint to get out unless there is some defect in joints, traps or connections. It is very simple as the test can be left on for any length of time without the plumber's presence.

Operation is simple and as follows:

Insert and secure the test plug on the increaser at roof. After the peppermint retainer is screwed into the soil stack, close doors and windows. Place the peppermint bottle in the retainer and screw down the cover tight; then turn the screw, breaking the peppermint bottle. Let hot water run slowly in the bath tub.

Any plumber is enough of a mechanic to make one of these containers himself out of pipe and malleable fittings. Container is to hold a three (3) ounce bottle.

Swimming Pools.

Swimming pools are one of the most popular recreations in connection with clubs, hotels and even private homes. They have become so numerous in the past few years that a great deal of attention is being given to the method of heating and purifying the water.

Besides the material used in the construction of the tank itself, which is white porcelain tile, the equipment of some of the swimming pools is almost a gymnasium erected over the water; trapeze, swinging rings extending a good portion over the length of the pool, toboggan slides, etc., are only a few of the amusements which make the swimming pool popular and healthful as a recreation with exercise combined.

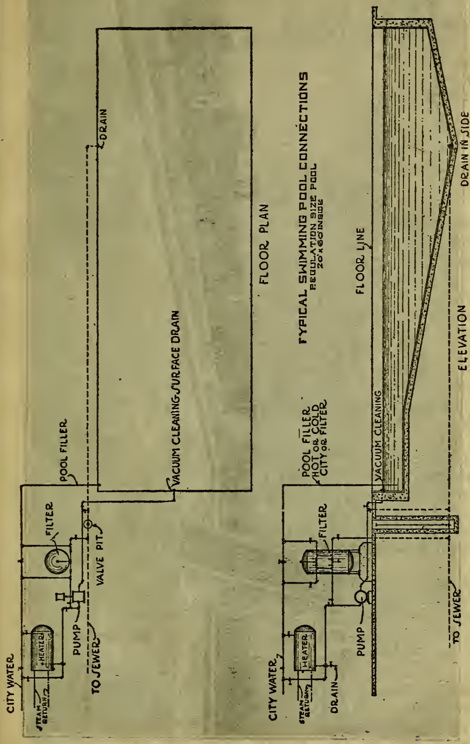
The standard size pool contains approximately 56,000 gallons of water; the bottom graduated from 2 feet to 8 feet in depth, which gives ample allowance for diving, plunging and swimming requirements. The width is approximately 24 feet, while the length is about 60 feet, this being the regulation size and which permits a large number of bathers to be accommodated at one time.

It is, nevertheless, a very important matter that the condition of the water should be given serious consideration—many bathers soon contaminate a water supply. Besides this fact, the water which is originally supplied to the pool (city water supply or river water supply as the case may be) should be filtered so that when the pool is filled to the brim you will be able to recognize a 10 cent piece lying flat on the bottom in the deepest place.

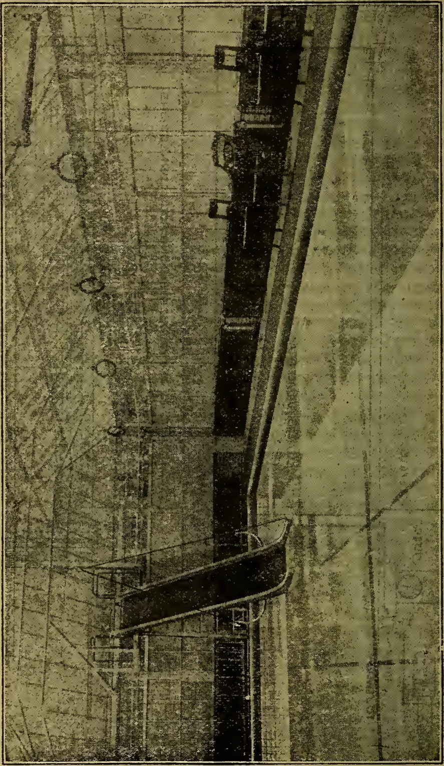
During the last few years, before cleaning the water in the pool was given much consideration, a person diving was not visible below the surface, which condition was responsible for a number of deaths either by accident or cramps, as the case might be, and when the body remained on the bottom of the pool it was not missed, in some instances from 12 to 18 hours. The possibility of this condition is entirely eliminated when a proper method of filtration is used. After the pool is first filled with clean, sparkling water, it should be circulated through the filter and back into the pool by using a pump and motor, which remain in constant duty when the pool is in service, thereby eliminating from the water in the pool all of the impurities accumulated, which will be caught in the filter and eventually washed to the sewer. The vacuum system used in connection with the same pump and motor is frequently used with the view of eliminating heavy suspension and cuticle which may adhere to the bottom of the pool and not be readily carried off by the general circulation. In many cases the hot water tank is eliminated and an automatic water heater is used with automatic gas attachment.

The systems which we have made a thorough and complete investigation on have been equipped with a most thorough and up-to-date apparatus, which is the Everson filter equipment. Illustrations of the pool shown herein has the very finest equipment possible to obtain. The water is filtered so thoroughly that it will magnify to such an extent that the pool does not look to be more than a foot deep, whereas in reality it is over 8 feet in depth.

Elevation and Drainage of Swimming Pools



These Illustrations Also Show Construction of Filters. Water May Circulate Through the Filter or Direct from Mains to Swimming Pool



Finished Installation

Heating Liquids by Steam.

In the design of a heater for water and other liquids, the two principal factors are the proper admission of steam and the rapid elimination of the condensation.

On the opposite page I call your attention to the Russell instantaneous heater for the heating of water for all kinds of commercial purposes. These heaters are made in the single compound and storage type. The shell and heads are of the best cast gray iron; the heating tubes are of wrought iron or seamless brass. The admission of the cold water and the delivery of the heated water are so arranged that same must come in contact with the entire tube surface.

In the compound heater, as illustrated, and which was designed for 10,000 gallons of water per hour from an initial temperature of 50 degrees to a terminal temperature of 185 degrees, 1¾-inch seamless brass tubes were used. Each tube had a separate ½-inch steam supply which delivered the steam to the extreme end of tubes before delivery to the 1¾-inch tubes. By this arrangement the water of condensation has but 6 feet to travel to reach condensation chamber provided in the heater.

The rapid delivery of the condensed water from the tubes renders the tube surface 96 per cent efficient. This construction gives the high heat transmission claimed and delivered by the Russell design.

So little is known by the average engineer and users of heaters regarding the amount of heating surface required; the B. T. U. transmission per square foot of surface; the pounds of steam condensed and other factors, that I insert a chart on an adjoining page which will enable engineers, heating contractors and users of heaters to figure out requirements.

The accompanying chart shows the relative efficiency of iron and brass pipe when used in storage heaters.

The following explains how to use the chart: First determine the number of pounds of steam required per hour to transmit the necessary number of heat units to raise the water to desired temperature.

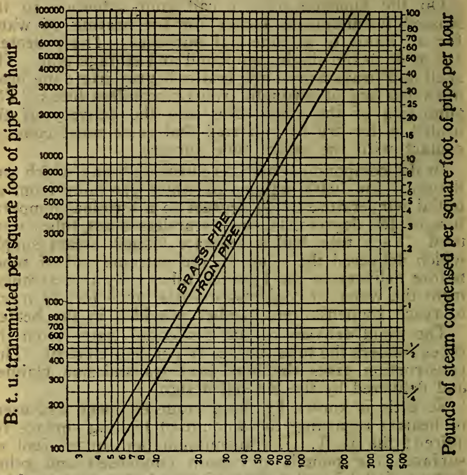
For example: The temperature of steam in pipes is 220 degrees; the initial temperature of the water is 50 degrees; the terminal temperature of the water is 190 degrees; thus the mean temperature of the water is 120 degrees. The difference in temperature of steam and water is 100 degrees.

On the bottom of chart you will note the difference

Heating Power of Brass and Iron Pipe

For Water Storage Tanks

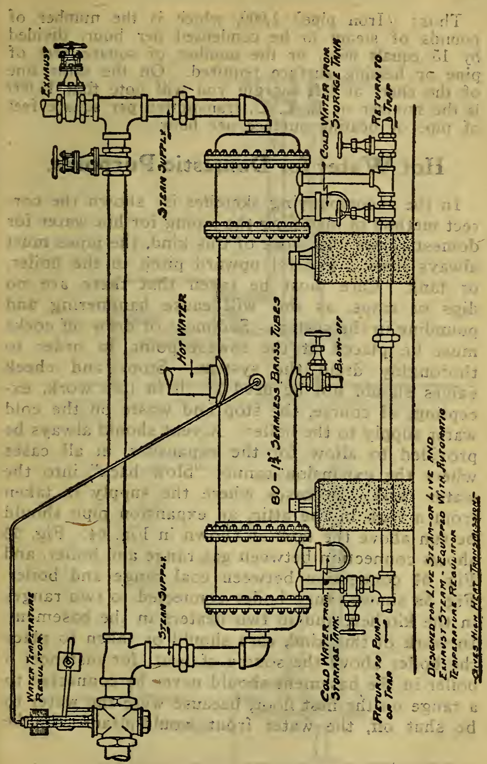
For use with Low Pressure Steam, up to 10 pounds by gauge. A "factor of safety" of 50% is included, to allow for fouling of pipe.



Temperature difference in Fahr. degrees between steam in coil and mean or average temp. of water in tank

in temperature, in Fahr. degrees, between the steam in the coil and the average temperature of water in the tank.

Follow the line marked 100 degrees upward to where it intersects with iron pipe line, then to the right to edge of chart marked 15. This indicates that 15 pounds of steam is condensed per hour per square foot of pipe. The required quantity of heating surface in square feet is determined by dividing the number of pounds of steam which must be condensed per hour by the number of pounds one square foot of pipe or heating surface will condense in one hour.



The best type of heater ever invented for heating water to a high temperature in an economical manner for boiler feed and domestic use.

Thus: (Iron pipe) 1,000, which is the number of pounds of steam to be condensed per hour, divided by 15 equals 66⅔, or the number of square feet of pipe or heating surface required. On the same line of the chart at left margin you will note that 15,000 is the number of B. T. U. transmitted per square feet of pipe or heating surface per hour.

Hot Water for Domestic Purposes.

In the accompanying sketches is shown the correct method of installing the piping for hot water for domestic uses. In work of this kind, the pipes must always have a general upward pitch to the boiler, or tank. Care must be taken that there are no dips or traps, as this will cause hammering and pounding in the system. Sediment or draw off cocks must be placed at the lowest point, in order to thoroughly drain the system. Stops and check valves should not be used at all in this work, excepting, of course, the stop and waste on the cold water supply to the boiler. A vent should always be provided to allow for the expansion, in all cases where the expansion cannot "blow back" into the water main. In cases where the supply is taken from a tank in the attic, an expansion pipe should be run above the tank as shown in Fig. 64. Fig. 56 shows connection between gas range and boiler, and Fig. 57 connection between coal range and boiler. Fig. 58 shows range boiler connected to two ranges in the kitchen, and to two heaters in the basement. In work of this kind, care should be taken to place the boiler above the source of heat; for instance, a boiler in the basement should never be connected to a range on the first floor, because were the water to be shut off, the water front would drain. If the

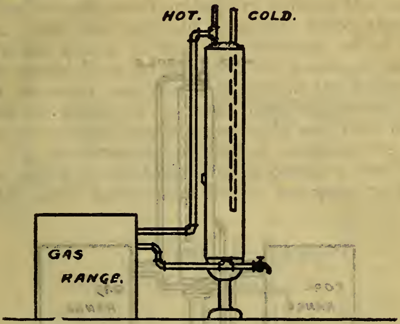


Fig. 56.

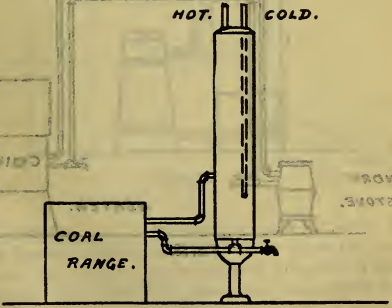


Fig. 57.

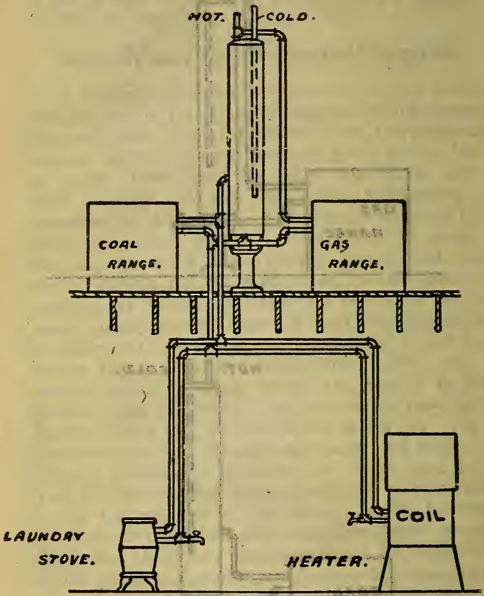


Fig. 58.

water were then turned on, the cold water entering the hot water front, would generate steam so quickly, that it would in all probability blow up the water front. With the boiler in its proper place, that is, above the source of heat, the shutting off of the water would have no effect on the boiler or water front, as water would still remain in the boiler to within six inches of the top. Figs. 59, 60, and 61, show the connections between tanks and tank heaters. Fig. 62 shows the method of installing the hot water piping to the fixtures in an ordinary dwelling, the hot water being taken from a hot water tank in

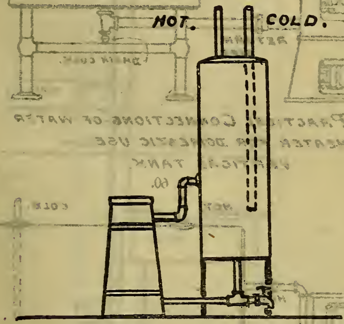
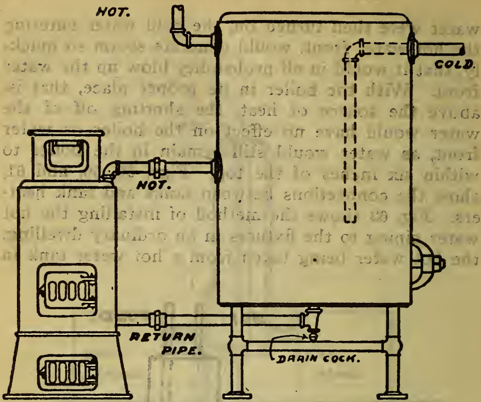


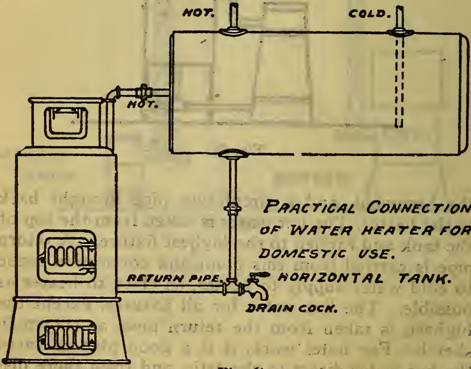
Fig. 59.

the basement, and a circulating pipe brought back to the heater. The hot water is taken from the top of the tank and carried to the highest fixture. A return pipe is carried from this point and connection made to cold water supply to heater, as close to heater as possible. The hot water for all fixtures, except the highest, is taken from the return pipe, as shown in sketch. For hotel work, it is a good plan to carry the hot water direct to the attic, and from there dis-



PRACTICAL CONNECTIONS OF WATER HEATER FOR DOMESTIC USE. VERTICAL TANK.

Fig. 60.



PRACTICAL CONNECTIONS OF WATER HEATER FOR DOMESTIC USE. HORIZONTAL TANK.

Fig. 61.

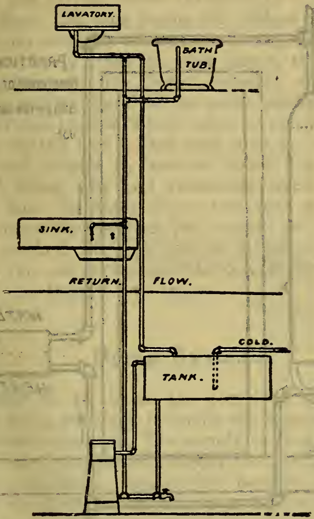


Fig. 62.

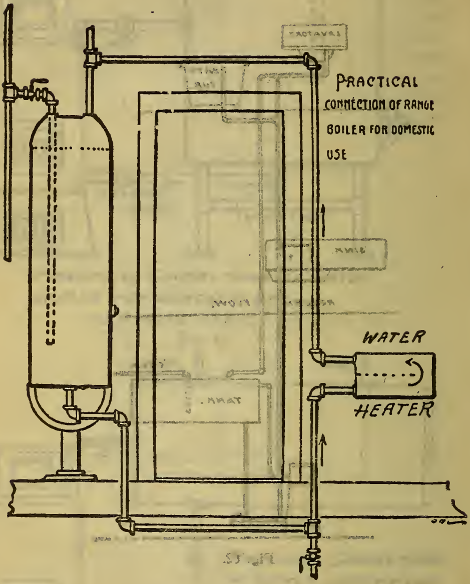

PRACTICAL
CONNECTION OF RANGE
BOILER FOR DOMESTIC
USE
WATER
HEATER

Fig. 63.

tribute it to the fixtures through the return risers. In Fig. 63 is shown the connection between range and boiler in cases where a door or window intervenes between boiler and range. A great deal of trouble is often caused from work installed as shown in Fig. 64. The hot water pipe is taken from the boiler and carried under the floor to a sink on the same floor, this sink being the highest fixture from which hot water is drawn. At times, the hot water will run freely from the sink faucet, then suddenly stop, although the faucet remains open. The trouble will be found at the point marked "X." To prevent this trouble, a vent must be carried as shown in the dotted line. This vent may be of ⅜" galv. pipe, and should be carried above the tank, and turned down, the end remaining open above the water line. In cases where this vent or expansion pipe cannot be installed, put a small pet cock at the point marked "X." In case of stoppage of the hot water, this pet cock should be opened for a few moments and trouble will cease.

Pump Systems.

In Fig. 65 is shown the complete hot and cold piping for a dwelling, in which the supply is pumped to a tank in the attic. The supply to tank from pump is also used for the cold supply to all fixtures. This supply enters the tank at the bottom, and at this point, in the tank, is placed a Tee with a check valve to prevent the water from entering the tank. The ball cock should be connected to the top of the Tee. An overflow should be taken from the tank and discharged to the nearest convenient place. A pressure gauge should be placed near the pump to show when system is filled.

In Fig. 66. is shown the method of installing a soft water system, using the city pressure for power to run the water lift. In work of this kind a faucet

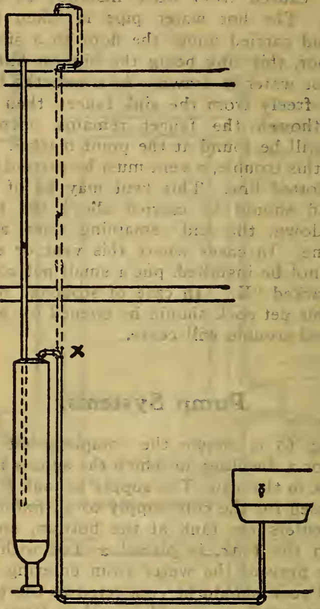


Fig. 64.

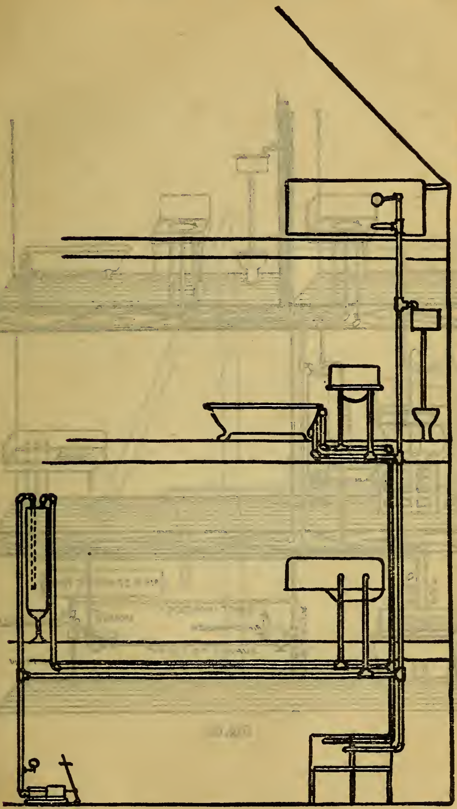


Fig. 65.

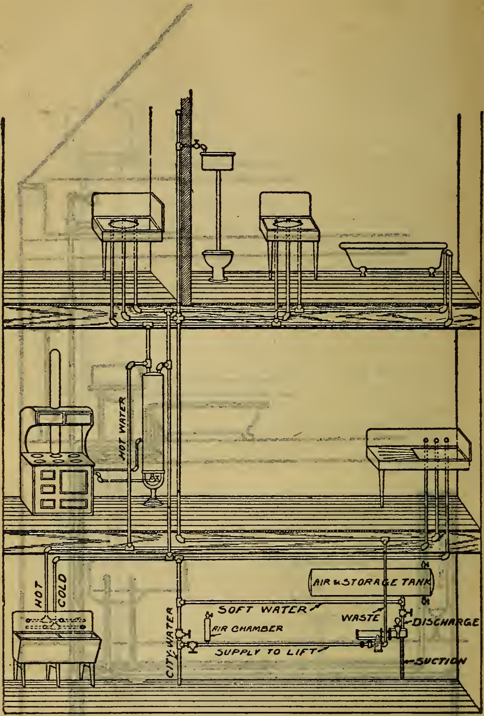
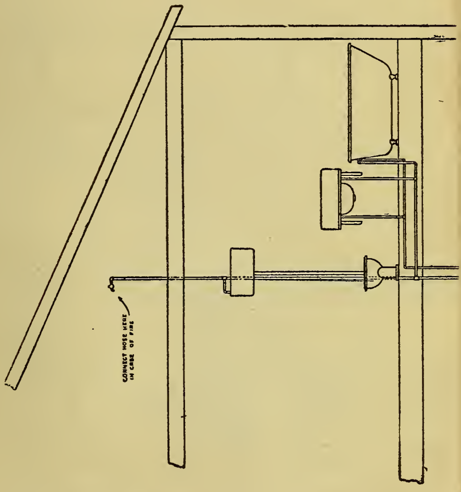
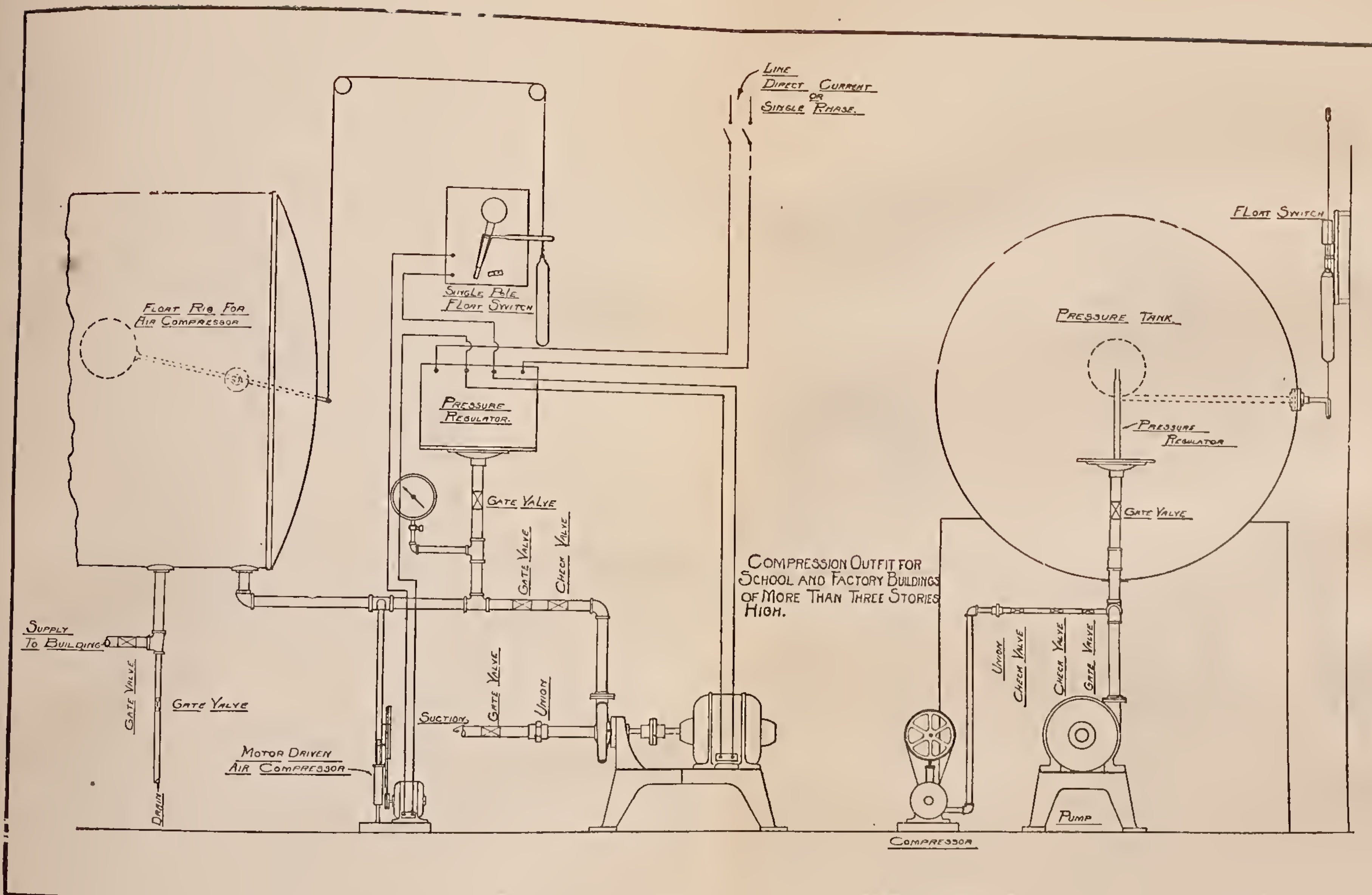

HOT WATER
HOT
COLD
CITY WATER
AIR & STORAGE TANK
SOFT WATER
WASTE
DISCHARGE
AIR CHAMBER
SUPPLY TO LIFT
SUCTION

Fig. 66


CONNECT HOSE HERE
IN CASE OF FIRE


Line
Direct Current
or
Single Phase.
Float Switch
Float Rig For
Air Compressor
Single Pole
Float Switch
Pressure
Regulator.
Pressure Tank.
Pressure
Regulator
Gate Valve
Gate Valve
Gate Valve
Check Valve
Compression Outfit for
School and Factory Buildings
of More Than Three Stories
High.
Supply
To Building
Gate Valve
Gate Valve
Suction
Gate Valve
Union
Motor Driven
Air Compressor
Drain
Union
Check Valve
Check Valve
Gate Valve
Compressor
Pump

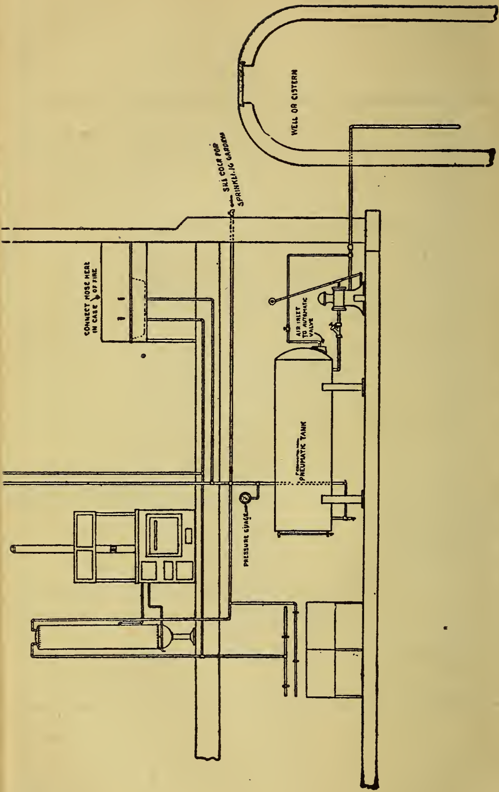
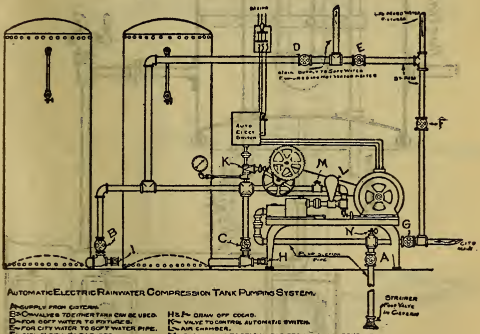

WELL OR CISTERN
CONNECT HOSE HERE IN CASE OF FIRE
AIR INLET TO AUTOMATIC VALVE
PNEUMATIC TANK
PRESSURE GUAGE

Fig. 67

for city water for drinking purposes is generally placed at each fixture, and the city water also supplies the water closet tanks. In this way the water used for power to run the water lift, is used instead of being wasted into the sewer. A storage tank should be placed in the attic with an over-flow, either directly back to the cistern, or out through the roof. The pipes in the basement should be so cross-connected as to by-pass the city water into the system in case of shortage of soft water.

Pneumatic Water Supply Systems.

In Fig. 67 is shown the method of installing the pneumatic water system which is coming into general use for farm houses, and in fact, is now being used to maintain pressure in municipal water plants.



AUTOMATIC ELECTRIC RAINWATER COMPRESSION TANK PUMPING SYSTEM.

A—Supply from cistern.
B & C—Valves so either tank can be used.
D—For soft water to fixtures.
E—For city water to soft water pipe.
F—City supply to fixtures.
G—City supply to pump.
H & I—Draw off cocks.
K—Valve to control automatic switch.
L—Air chamber.
M—Check valve to stop water from backing up to pump.
N—Air cock to let out air.

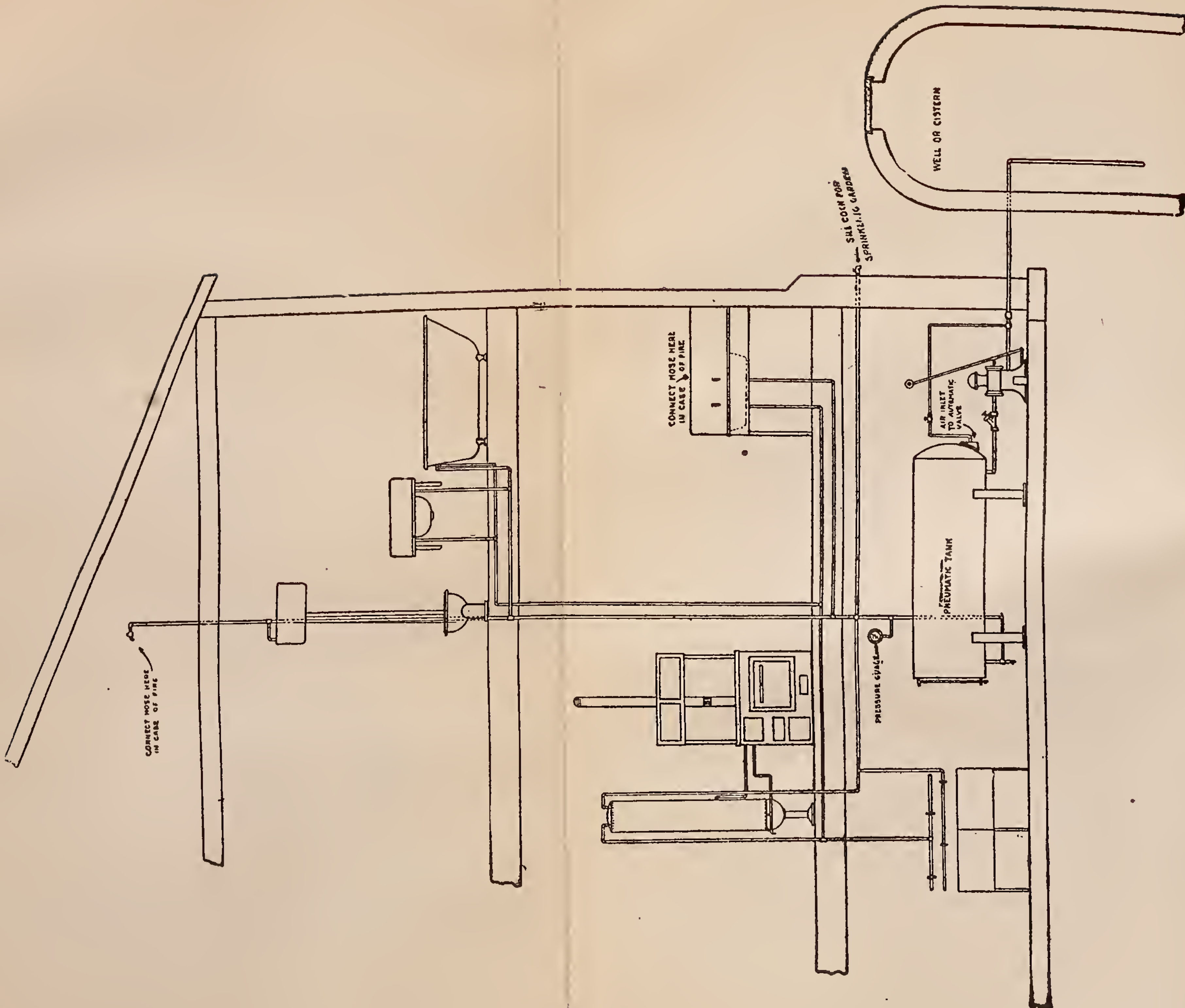
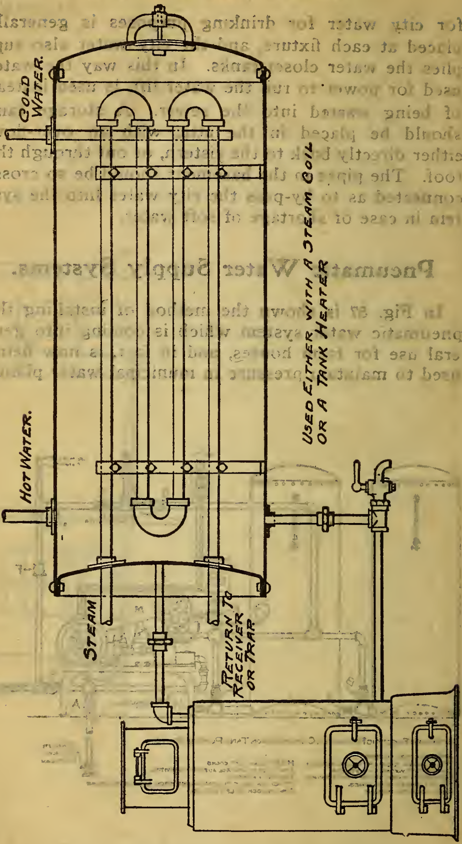

WELL OR CISTERN
CONNECT HOSE HERE IN CASE OF FIRE
AIR INLET TO AUTOMATIC VALVE
PNEUMATIC TANK
PRESSURE GUAGE
CONNECT HOSE HERE IN CASE OF FIRE

Fig. 67



This is the proper way to build a coil to be installed in a tank, for domestic use

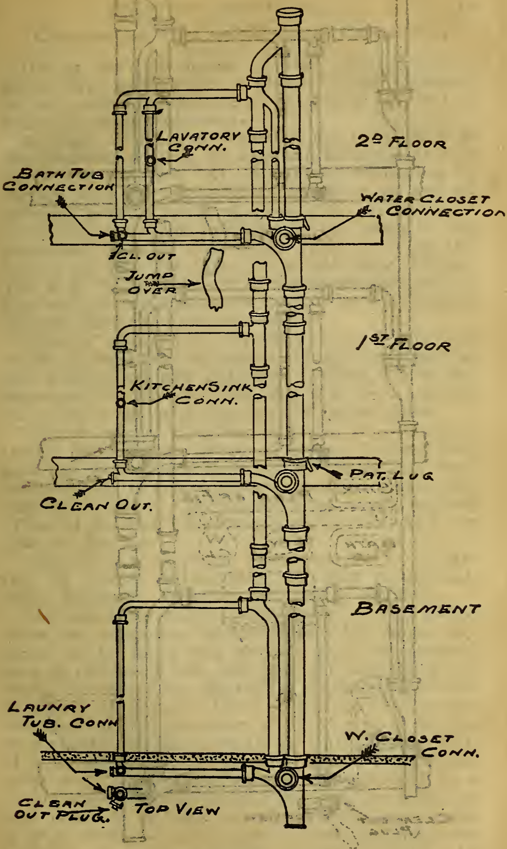

LAVATORY
CONN.
2º FLOOR
BATH TUB
CONNECTION
WATER CLOSET
CONNECTION
CL. OUT
JUMP
OVER
1ST FLOOR
KITCHEN SINK
CONN.
PAT. LUG
CLEAN OUT.
BASEMENT
LAUNRY
TUB. CONN
W. CLOSET
CONN.
CLEAN
OUT PLUG.
TOP VIEW

FIG. A.

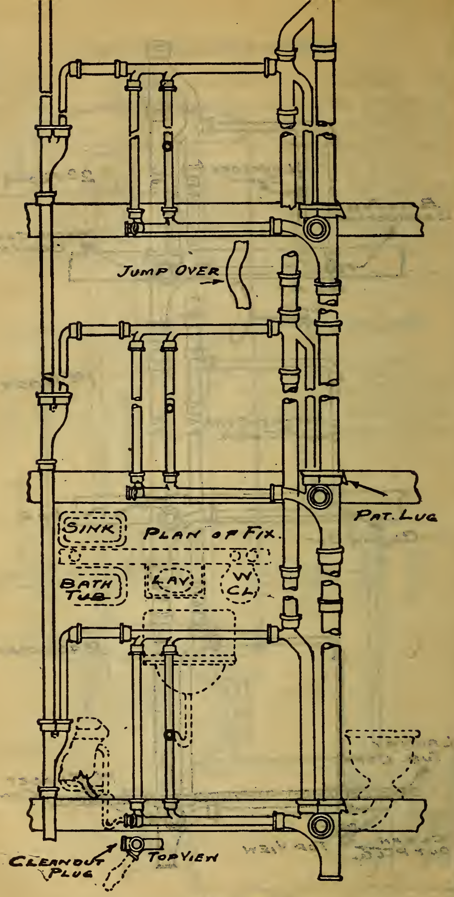

JUMP OVER
PAT. LUG
SINK
PLAN OF FIX.
BATH TUB
LAV.
W. CL.
CLEANOUT PLUG
TOP VIEW

FIG. B.

Combination Vent and Drainage Connections

During the last decade or two, great advancements have been made in plumbing and drainage. In fact, what was considered perfection only a few years ago, is now obsolete.

Amongst all the improvements, the so-called F & W Combination Vent, Re-vent and Drainage fittings easily take the lead. As all re-vent connections to the soil stack are connected by means of 45° and all so-called pockets are done away with. It absolutely prevents any rust or sediment to lodge in the bends and thereby, after a few years, close up the re-vent as was the case in the old style fittings. The F & W system is now considered the perfection and is compulsory in several of the largest cities in both the east and west.

"Fig. A" shows the customary way of roughing in for a two-story and basement residence having one water-closet and stationary laundry tub in the basement, kitchen sink on the first floor, water-closet, bath tub, and lavatory on second floor.

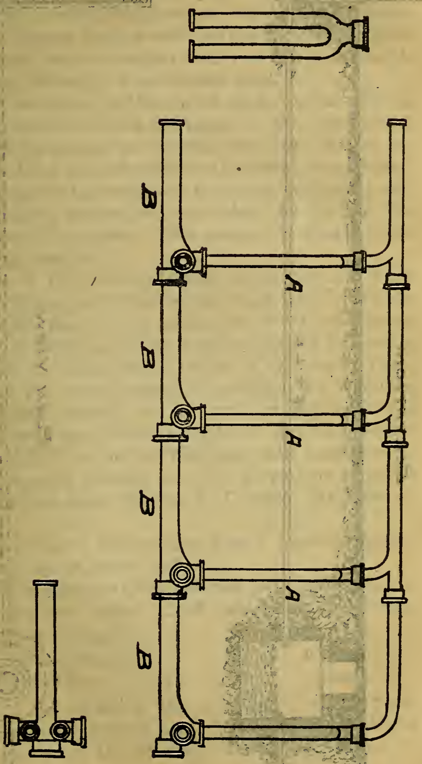
"Fig. B" shows roughing in for a two, or more, stories flat building. Here, of course, kitchen sink, bath tub, water-closet and lavatory are on one floor and roughing in repeated for as many stories as the building contains. The dotted lines, where marked "Plan of fixtures," shows a partition wall and the different fixtures.

"Fig. C" is an elevation of roughing in for a battery of double water-closets as used in schools, office buildings, factories and public buildings.

For houses in towns and country places, where there are no sewers, the soil from a full line of fixtures can be taken care of in a perfectly sanitary way by building a cess pool of either brick or wood, 25 feet or more from the rear of the building. If the cess pool is of wood, holes of 1½" or 2" diameter should be drilled on about 4" or 6" centres all the way around and for a height of three to four feet. If of brick, use good hydraulic cement mortar and leave a 2" opening at frequent intervals and to a height slightly below the soil pipe. A run from the cess pool can be made to distribute the water over a larger area. If such a run is made, lay the pipes without any cement joints, thereby letting the water run out at every joint.

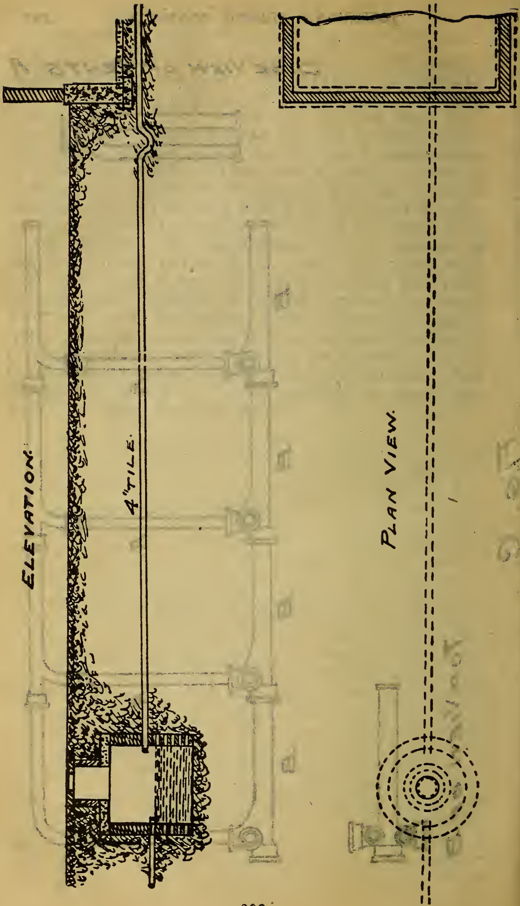
For an ordinary residence having two water-closets, laundry tub, sinks, two lavatories and a bath tub, a cess pool eight feet in diameter has been found ample. Wall should not be less than 8½" thick. A good way to make the top is to place ¾" W. T pipes about 6" apart, but leaving a space about 2' 6" in the middle. Then lay another course, at right angles to the first course, leaving also an opening 2' 6". You have now a skeleton cover looking like the wires of a sieve, with a 2' 6" square hole in the middle. On this framing lay, in cement, a course of brick, flat ways, and when set finish with a 6" to 8" thick course of concrete of the following proportions: One part Portland cement, two parts Torpedo sand, and three parts of coarse gravel. After a day or two, when the concrete is thoroughly set, build up with brick laid in cement, a 2' 6" round extension to within 4" of the surface. On top of this, place a 4" thick cement or stone ring with cast iron manhole cover.

SIDE VIEW OF VENTS A



TOP VIEW OF B

FIG. C.


ELEVATION.
4" TILE.
PLAN VIEW.

The Art of Soldering.

The term "soldering" is generally applied when fusible alloys of lead and tin are employed for uniting metals. When hard metals, which melt only above a red heat, such as copper, brass or silver are used, the term "brazing" is sometimes used.

Hard soldering is the art of soldering or uniting two (2) metals or two (2) pieces of the same metal together by means of a metal or solder that is almost as hard and infusible as the metal to be united In some cases the metals to be united are heated and their surface united without solder by fluxing the surface of the metals. This process is then termed "burning together."

Some of the hard soldering processes are often termed "brazing." Both brazing and hard soldering are usually done in the open fire or with a brazing torch. A soldering joint is more perfect and more tenacious as the point of fusion of the solder rises.

Thus: Tin, which greatly increases the fusibility of its alloys, should not be used for solder, except when a very easy running solder is wanted. Solder made with tin is not so malleable and tenacious as those prepared without it. The Egyptians soldered with lead as long ago as B. C. 1490, the time of Moses.

Pliny refers to the art, and says it requires the addition of tin to use as solder.

Another solder, a very odd but very good one for some purposes, called "Cold Solder" is as follows:

Steel Filings	2 oz.
Brass Filings	2 oz.
Fluric Acid	1¼ oz.

Dissolve the filings in the acid, apply to the parts to be soldered, having first cleaned the parts to be connected, keep the acid in a lead vessel only.

Advantage may be taken of the varying degrees of fusibility of solders to make several joints in the same piece of work. Thus, if the first joint has been made with the fine tinner's solder, there would be no danger of melting it in making a joint near it with bismuth solder.

The fusibility of soft solder is increased by adding bismuth to the composition. An alloy of lead, 4 parts, tin 4 parts and bismuth 1 part, is easily melted, but this alloy may itself be soldered with an alloy of lead 2 parts, bismuth 2 parts, and tin 1 part. By adding mercury with 2 parts of tin will make a composition which melts at 122 degrees Fahr., or taken in this order for the same work.

First	1 tin	2 lead		
Next	1 tin	1 lead		
Next	4 tin	4 lead	1 bismuth	
Next	2 lead	1 tin	2 bismuth	
Next	1 lead	1 bismuth	1 mercury	2 tin
Next	3 lead	3 bismuth	5 tin	
Next	5 lead	8 bismuth	3 tin	

Solders.

To solder lead	1 tin	2 lead
To solder tin	1 tin	1 lead
To solder pewter	2 tin	1 lead

Spelters.

for brazing:

Spelter	Hardest	3 copper	1 zinc	
Spelter	Hard	1 copper	1 zinc	
Spelter	Soft	4 copper	3 zinc	1 tin
Spelter	Very Soft	1 antimony		2 tin
Spelter	For Platina is Gold.			

Spelter for gold; 2 parts gold, 1 part silver, 1 part copper.

Spelter for silver; 4 parts silver, 3 parts brass, 1/16 part zinc.

Spelter for iron (hard); silver solder, 7 parts brass, 1 part zinc.

Spelter for iron (soft); 1 part tin, 1 part lead.

Spelter for brass and copper (hard); brass mixed with ½ to 1/5 or ½ of zinc.

Spelter for brass and copper (soft); 1 part tin, 1 part lead.

Spelter for pure tin; 4 parts pewter, 1 tin, 1 bismuth.

Spelter for very soft solder; 3 parts bismuth, 3 lead, 5 tin.

Metal which melts at a heat not exceeding boiling water is 8 parts bismuth, 5 lead and 3 of tin.

An Old but Exceedingly Good Method of Lead Burning.

The apparatus required is a cast-iron furnace, two or three ladles, and some moulding sand. Burning is resorted to by plumbers generally for purposes where soldering will not stand.

Cast a sheet of lead of the proper thickness, and cut the proper length and width, turn it up round like a hoop, bringing the two ends well together to form a good joint on the outside, and firmly tack them together on the inside; roll it over to see that the joint is close on the outside, and paste a piece of stout brown paper about 4 inches wide over the whole length of the joint.

The sand must be well tempered, not to have any wet lumps in it; make a level bed with the sand about 5 or 6 inches thick; roll the hoop on the sand so that the joint will come under, be careful not to shift it backwards or forwards, but well ram up under both sides. Have a strip of wood rather longer than the joint, and ¾-inch thick, to form the runner with, place it along on edge on the top of the joint; now place some sand both sides and ram it well together,

adding sand until there is a good bank on the top of the work; smooth it off with a trowel, cut it down towards the strip, so as to form a sort of funnel, leaving about 2 inches of the strip buried; draw out the strip endways, being careful not to break the sand, leaving one end stopped up, the other end stopped up about one inch high. At this end make a bay or pond for the overflow metal to run into. Have the metal red hot, be careful that the runner is free from loose sand, shake a little powdered rosin along the runner. Now begin to pour the metal, holding the ladle at least one foot above the runner so as to give weight and force to the burning metal; pour plenty, not minding what is running off, as the metal that is pouring in has to melt the part which is in the cold sand. When the joint is burned through try it by drawing the trying stick along in the runner; if it feels smooth along the bottom it is burned, if not, pour some more until it is, then stop up the end where the metal has been running off, and fill up about two inches high, and watch for shrinkage, having some hot metal ready to fill up as it shrinks down in cooling, or else the joint will not be round. When set, remove it from the sand, and cut off the runner with a mallet and chisel, finishing off with a piece of card wire, the paper on the outside will strip off, leaving it bright and clean.

Having now completed this part and set it up, round in shape, proceed with burning in the bottom; having a hole or pit in the floor, deep enough for the hoop to go down level with the floor, placing it in perfectly level. Fill up with the sand inside and out rather slackly. When filled up within four or five inches from the top, ram it down for the other part quite hard on the outside, leaving the sand rather higher than the edge; then with a straightedge scrape off level with the edge of the lead. Now with a scribe

take out the sand the thickness of the required bottom, plane the sand off with a trowel, and the work will turn out clean. The sand on the outside being up level with the edge, smooth off, and cut a bay all around to take the overflow, shake a little rosin around the edge; having the metal red hot, begin to pour as before, only this is a work for two or three persons if it is any size, as it must be done quickly, pouring the metal along the edge until it is properly burned down; when it is burned deep enough, pour a few ladlefuls all over the bottom, so as to get in a thoroughly fluid state; then with the edge of the trowel clean off the dross, leaving a perfectly bright surface. Let it remain to set. This will not require any filling up, as it is open to the air and shrinks; when set it may be removed, and if well burned it will be perfectly solid.

Useful Information

Minimum Sizes of Local Vent Pipe Stacks

Size of Pipe	Maximum developed length in feet Mains	Number of Closets vented Vent Branches	Main Vertical Vent
2 inches	400	1	1
3 inches	100	3	6
4 inches	150	6	12
5 inches	200	10	20
6 inches	250	16	32
7 inches	300	23	46
8 inches	350	32	64
9 inches	400	42	84
10 inches	450	56	112
11 inches	500	72	144
12 inches	550	90	180

Check Valves Should Never be Used on Circulation.

While this is true as a general proposition, there are some cases where a check valve is necessary, to prevent the water from reversing in the circulating pipe. In cases of this kind use a horizontal check valve and place it as near the boiler as possible. The check valve should be installed so that the water cannot flow through check valve from boiler.

Size of Pipe	Branch Soil Pipe Water Closets	Main Soil Pipe Water Closets
2 inches	...	...
3 inches	...	...
4 inches	8	16
5 inches	18	36
6 inches	36	72
7 inches	63	126
8 inches	105	210

Minimum Sizes of Soil and Waste Pipes.

Size of Pipe.	Branch Waste and Connecting Soil Pipe. Fixtures.	Main Waste and Connecting Soil Pipe. Fixtures.
2 inches	3	4
3 inches	4	8
4 inches	32	64
5 inches	72	144
6 inches	144	288
7 inches	252	504
8 inches	420	840

Hammering or jarring in the pipes may be caused by a loose part of one of the faucets or ball cocks. A loose Fuller ball or washer will cause a rattling in pipes that can be heard throughout the house.

Doubling the size of pipes increases the capacity four times, because capacities of pipes are to each other as the ratio of their squares. Thus the capacity of 4″ pipe is 4 times as great as the capacity of 2″ pipe. The capacity of 6″ pipe is 9 times as great as the capacity of 2″ pipe. The method of reaching these conclusions is as follows: The large pipe 4″ multiplied by itself, 4×4=16. The small pipe, 2″ multiplied by itself 2×2=4. 16÷4=4: Therefore the capacity of 4″ pipe is 4 times as great as the capacity of 2″. 6×6=36. 2×2=4. 36÷4=9. Therefore the capacity of 6″ pipe is 9 times as great as the capacity of 2″.

To multiply feet and inches by feet and inches, without reducing to inches. This is useful to the plumber in figuring marble.

For example take 4 ft. 6 in. by 6 ft. 3 in.

4 — 6	4 ft.x6 ft.=	24 ft.
6 — 3	6 in.x6 ft.=36 in. or	3 ft.
24 1½	4 ft.x3 in.=12 in. or	1 ft.
3	6 in.x3 in.=18/12 in. or	1½ in.
1	Total..	28 ft. 1½ in.
28 — 1½		

An insertable joint will save time and trouble in cases where it is necessary to break into a stack.

Things We All Should Know.

If back outlet closets and graduated fittings are used when installing a battery of closets, it will be unnecessary to put in a raised floor. These closets and fittings are carried in stock by the leading supply houses, and the fittings are of sufficient length to allow one to each closet without the necessity of using pieces of soil pipe between the fittings.

In estimating water for factory supply, allow 100 gallons per day per capita.

Soft water cisterns must be ventilated to prevent stagnation.

Storage tanks should have an extra large sediment draw off cock to be used solely for cleaning tank. It is a regretable fact that the majority of storage tanks are seldom cleaned.

Hammering, rumbling or snapping in the range boiler or hot water pipes is caused from sagging of the pipes, causing traps or dips or from stoppage in the water front.

Water fronts should never be connected directly to the city pressure. The cold water supply to the water front should be taken from the bottom of the range boiler.

Use a small offset between sink and sink trap as shown in Fig. 43, page 255. This will prevent the annoying constant dripping noise in the sink.

Very often it will be found economical to waste all the fixtures but the closet, into the 2" sink stack. In cases of this kind the closet need not be revented as it is the only fixture wasting into the 4" stack.

House sewers should have a pitch of ¼" to the foot.

Automatic closets and urinals should always be used in schools and factories.

In cities where the water pressure is increased in case of fire, a pressure regulator should be used, or the house should be supplied from a tank in the attic. If the tank system is used, the extra fire pressure does not affect the fixtures or piping.

It is poor practice to connect sediment pipe from range boiler to the sink trap. It is far better to use a compression bibb, as this precludes the possibility of waste, and the plumber knows for certainty that the system is drained.

File or drill a small hole in boiler tube about 6" from the top to prevent syphonage of boiler.

The circulating pipe should be of the same size as the flow pipe, and to insure best results, take supply to fixtures from return or circulating pipe.

Hot water faucets should be at the left hand when facing the fixture.

Stops should never be used on range boiler supply. Always use stop with waste to give vent to boiler when water is shut off.

Coils in furnaces should be placed above the bed of fire, not in it.

The Sanitary-perfect Screw Connection

As Manufactured and Furnished by The J. L. Matt Iron Works of New York

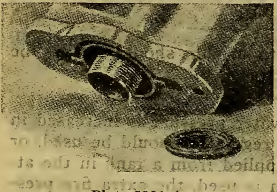


Plate 5001-A

In these days of almost perfection in sanitary science, the connection of the water closet to the soil pipe is the one weak spot in an otherwise admirable system of house plumbing, the one connection that cannot be relied upon under all conditions. That absolute security is assured, and the question of careless or unskilful work disposed of by the sanitary-perfect screw connection, must be admitted by all; moreover, those who have seen and used this devise do not hesitate to say that it solves the question of water closet connection, and state, furthermore, that knowing such device to exist they would feel in duty bound to recommend the same to their clients as the only perfect connection which they could guarantee under all conditions.

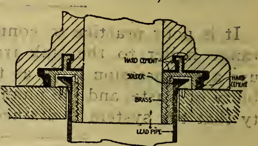


Plate 5002½-A

NOTE.—All ordinary connections require bolts through the base of the closet. The sanitary-perfect is a screw connection, hence is absolutely and permanently reliable and furthermore it dispenses with unsightly bolts.

Plate 5002½-A shows closet with the sanitary-perfect screw connection and the threaded floor coupling which is connected to soil pipe.

The section of the sanitary-perfect screw connection (Plate 5001-A) shows how the threaded brass screw connection is secured into the base of the closet. The joint thus formed makes the brass connection equivalent to an integral part of the closet which is impossible to loosen or disturb in the slightest degree, the taper thread insuring against leakage.

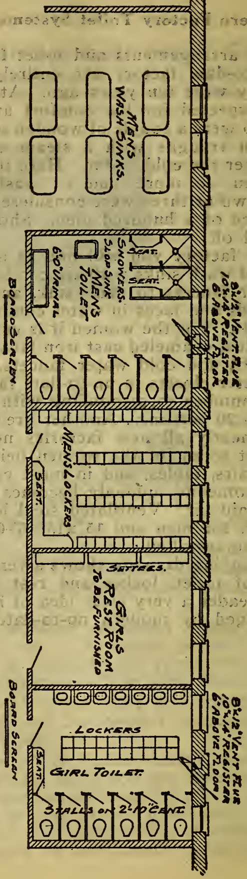
Modern Factory Toilet Systems

The sanitary arrangements and toliet facilities of a modern up-to-date factory are entirely different from what they were ten years ago. At that time all that was expected for the comfort and cleanliness of the help were a couple of wooden or, perhaps, black cast iron troughs with a steam coil in the trough to temper the cold water. Here in the same water, a dozen or more had to wash. As for water closets, two or three were considered sufficient even for a force of a hundred men. Showers were things unheard of.

In a modern factory you will find as a rule, 30"-x6'-0" enameled wash sinks with six combination hot and cold water faucets to each sink, and the men wash their hands and faces in water coming directly from the faucets. For the women it is customary to arrange individual enameled cast iron lavatories with combination hot and cold water faucets.

As a rule water closets in up-to-date factories are installed to a number corresponding with one closet for every 15 to 20 persons. Another great improvement is that nearly all new factories now have a good sized rest room for the women help in which are settees, chairs, tables, and in most cases, a cot, to be used if someone suddenly becomes ill. There is also a first aid set. Ventilated steel lockers 12"-x12"x5'-0" high for men and 15"x15"x5'-0" high for women are also installed.

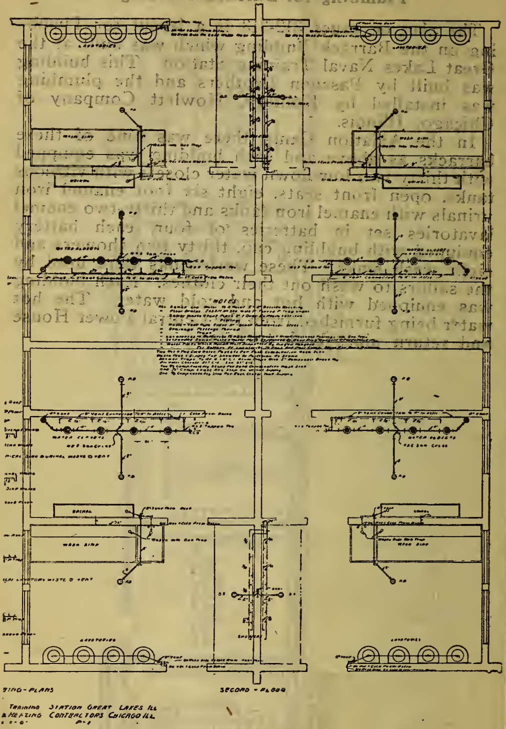
The accompanying drawing shows a very complete arrangement of toilet, locker and rest rooms and will give the reader a very clear idea of how toilets, etc. are arranged by modern up-to-date industrial engineers.

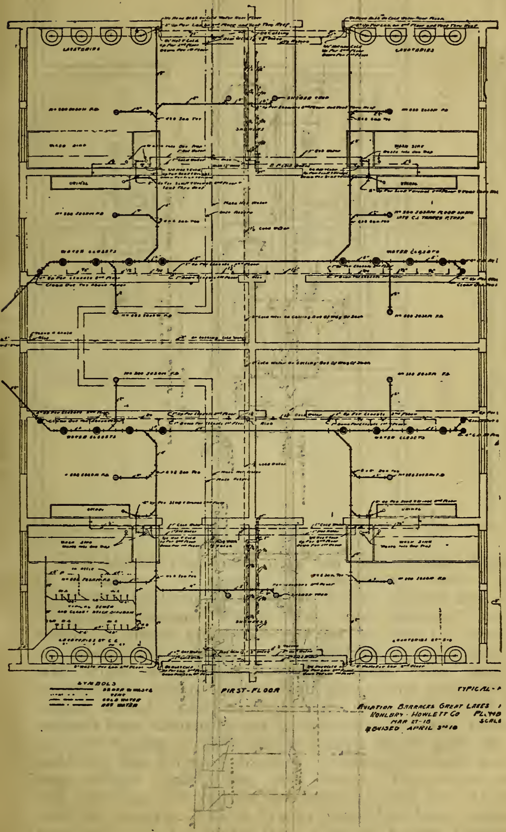

MEN'S WASH SINKS.
SEAT.
SEAT.
SHOWERS.
SLOP SINK
MEN'S TOILET
6'0" URINAL
BOARD SCREEN
8x12" VENT FLUE 10x14" REGISTER 6" ABOVE FLOOR
MEN'S LOCKERS
SEAT.
SETTEES.
GIRLS REST ROOM TO BE FURNISHED
LOCKERS
SEAT.
GIRL TOILET.
STALLS ON 2-10" CENT.
BOARD SCREEN
8x12" VENT FLUE 10x14" REGISTER 6" ABOVE FLOOR

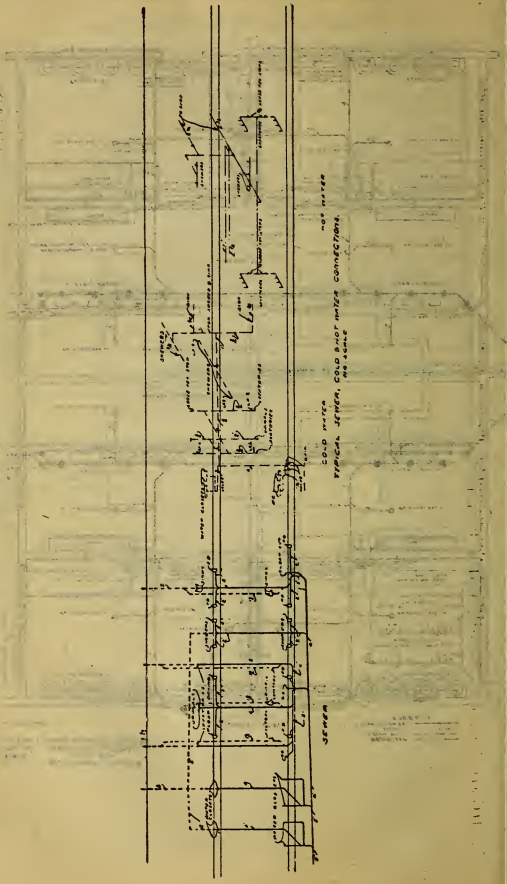
Plumbing for Barrack Buildings

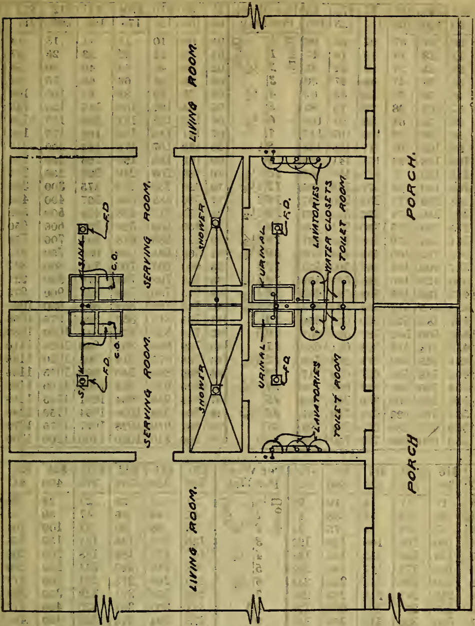
The plan on pages 312-313 is a layout for Plumbing on the Barrack Building which was built at the Great Lakes Naval Training Station. This building was built by Paschen Brothers and the plumbing was installed by Kohlbry, Howlett Company of Chicago, Illinois.

In the Aviation Camp there was nine of these barracks as above and each building was equipped with thirty-two low down water closets with vitreous tanks, open front seats, eight six foot enamel iron urinals with enamel iron tanks and thirty-two enamel lavatories set in batteries of four, each battery equipped with bubbling cup, thirty two showers and eight wash sinks. These wash sinks were used by the sailors to wash out their clothes. Each building was equipped with hot and cold water. The hot water being furnished from the Central Power House and return pipes back to same.


LAVATORIES
SECOND - FLOOR
TRAINING STATION GREAT LAKES ILL
HEATING CONTRACTORS CHICAGO ILL


SYMBOLS
COLD WATER
HOT WATER
FIRST-FLOOR
TYPICAL-
AVIATION BARRACKS GREAT LAKES
KOHLBRY · HOWLETT CO
MAR 27-18
REVISED APRIL 3RD 18


TYPICAL SEWER, COLD & HOT WATER CONNECTIONS.
NO SCALE
HOT WATER
COLD WATER
SEWER
SHOWERS



The above plan and plan on preceeding page is a layout of piping for plumbing work in Barracks Building located at Great Lakes Naval Training Station. There was one hundred and three of these buildings put up in the Isolation and Detention Camps. Each building was equipped with eight water closets with open front seats operated by Sloan Valves, four three foot enameled lipped urinals and enamel iron tank and twelve enamel iron lavatories set in batteries of three, each battery equipped with hot and cold water and one bubbling cup for each battery. Twelve showers and four double Galvanized iron sinks. One side of the sink was for sterilizing purposes and the other side for rinsing. Thirty-five of these buildings were equipped with hot water from Central Power House and sixty eight of them had individual hot water tanks.

EIGHT HOUR DAY WAGES TABLE—48 Hours Per Week

$5 83	$5½ 92	$6 100	$6½ 108	$7 117	$7½ 125	$8 133	Per Week Per Day. Hours.	Days	$½ 08	$9 150	$10 167	$10½ 175	$11 183	$12 200	$13 217	$13½ 225	$14 233
05	06	07	07	07	08	08	½		01	09	10	11	11	13	14	14	1
10	11	13	14	15	16	17	1		01	19	21	22	23	25	27	28	2
21	23	25	27	29	31	33	2	¼	02	38	42	44	46	50	54	56	5
31	34	38	41	44	47	50	3		03	56	63	66	69	75	81	84	8
42	46	50	54	58	63	67	4	½	04	75	83	88	92	100	108	113	11
52	57	63	68	73	78	83	5		05	94	104	109	115	125	135	141	14
63	69	75	81	88	94	100	6	¾	06	113	125	131	138	115	0163	169	17
73	80	88	95	102	109	117	7		07	131	146	153	160	175	190	197	20
83	92	100	108	117	125	133	8	1	08	150	167	175	183	200	217	225	23
94	103	113	122	131	141	150	9		09	169	188	197	206	225	244	253	26
104	115	125	135	146	156	167	10	1¼	10	188	208	219	229	250	271	281	29
125	138	150	163	175	188	200	12	1½	13	225	250	263	275	300	325	338	35
167	183	200	217	233	250	267	16	2	17	330	333	350	367	400	433	450	46
208	229	250	271	292	313	333	20	2½	21	375	417	438	458	500	542	563	58
250	275	300	325	350	375	400	24	3	25	450	500	525	550	600	650	675	70
292	321	350	379	408	438	467	28	3½	29	525	583	613	642	700	758	788	81
313	344	375	406	438	469	500	30	3¾	31	563	625	656	688	750	813	844	87
333	367	400	433	467	500	533	32	4	33	600	667	700	733	800	867	900	93
354	390	425	460	496	531	567	34	4¼	35	638	708	744	779	850	921	956	92
375	413	450	488	525	563	600	36	4½	38	675	750	788	825	900	975	1013	105
396	435	475	515	554	594	633	38	4¾	40	713	792	831	871	950	1029	1069	110
406	447	488	528	569	609	650	39		41	731	813	853	894	975	1056	1097	113
417	458	500	542	583	625	667	40	5	42	750	833	875	917	1000	1083	1125	116
427	470	513	555	598	641	683	41		43	769	854	897	940	1025	1110	1153	119
438	481	525	569	613	656	700	42	5¼	44	788	875	919	963	1050	1138	1181	122
448	493	538	582	627	672	717	43		45	806	896	940	985	1075	1165	1209	125
458	504	550	596	642	688	733	44	5½	46	825	917	963	1008	1100	1192	1238	128
469	516	563	609	656	703	750	45		47	844	938	984	1031	1125	1219	1266	131
479	527	575	623	671	719	767	46	5¾	48	863	958	1006	1054	1150	1246	1294	134
490	539	588	636	685	734	783	47		49	881	979	1028	1077	1175	1273	1322	137
500	550	600	650	700	750	800	48	6	50	900	$10	1050	1100	1200	1300	1350	140

$15 250	$16 267	$16½ 275	$17 283	$18 300	$19½ 325	Per Week Per Day Hours.	Days.	$20 333	$21 350	$22 367	$22½ 375	$24 400	$25 417	$27 450	$3 5
16	17	17	18	19	20	½		21	22	23	23	25	26	28	3
31	33	34	35	38	41	1		42	44	46	47	50	52	56	6
63	67	69	71	75	81	2	¼	83	88	92	94	100	104	113	12
94	100	103	106	113	122	3		125	131	138	141	150	156	169	18
125	133	138	142	150	163	4	½	167	175	183	188	200	208	225	25
156	167	172	177	188	203	5		208	219	229	234	250	260	281	31
188	200	206	213	225	244	6	¾	250	263	275	281	300	313	338	37
219	233	241	248	263	284	7		292	306	321	328	350	365	394	43
250	267	275	283	300	325	8	1	333	350	367	375	400	417	450	50
281	300	309	319	338	366	9		375	394	413	422	450	469	506	56
313	333	344	354	375	406	10	1¼	417	438	458	469	500	521	563	62
375	400	413	425	550	488	12	1½	500	525	550	563	600	625	675	75
500	533	550	567	600	650	16	2	667	700	733	750	800	833	900	100
625	667	688	708	750	813	20	2½	833	875	917	938	1000	1042	1125	125
750	800	825	850	900	975	24	3	1000	1050	1100	1125	1200	1250	1350	150
875	933	963	992	1050	1138	28	3½	1167	1225	1283	1313	1400	1458	1575	175
938	1000	1031	1063	1125	1219	30	3¾	1250	1313	1375	1406	1500	1563	1688	187
1000	1067	1100	1133	1200	1300	32	4	1333	1400	1467	1500	1600	1667	1800	200
1063	1133	1169	1204	1275	1381	34	4¼	1417	1488	1558	1594	1700	1771	1913	212
1125	1200	1238	1275	1350	1463	36	4½	1500	1575	1650	1688	1800	1875	2025	225
1188	1267	1306	1346	1425	1544	38	4¾	1583	1663	1742	1781	1900	1979	2138	237
1219	1300	1341	1381	1463	1584	39		1625	1706	1788	1828	1950	2031	2194	243
1250	1333	1375	1417	1500	1625	40	5	1667	1750	1833	1875	2000	2083	2250	250
1281	1367	1409	1452	1538	1666	41		1708	1794	1879	1922	2050	2135	2306	256
1313	1400	1444	1488	1575	1706	42	5¼	1750	1838	1925	1969	2100	2188	2363	262
1344	1433	1478	1523	1616	1747	43		1792	1881	1971	2016	2150	2240	2419	268
1375	1467	1513	1558	1650	1788	44	5½	1833	1925	2017	2063	2200	2292	2475	27
1406	1500	1547	1594	1688	1828	45		1875	1969	2063	2109	2250	2344	2531	28
1438	1533	1581	1629	1725	1869	46	5¾	1917	2013	2108	2156	2300	2396	2588	28
1469	1567	1616	1665	1763	1909	47		1958	2056	2154	2203	2350	2448	2644	29
1500	1600	1650	1700	1800	1950	48	6	2000	2100	2200	2250	2400	2500	2700	300

At $9 per Week ($1.50 per Day), the Wages for 46 Hours (5¾ Days) amount to $8.63.

TABLE showing EQUIVALENT of several Discounts; Proceeds on $; Profit on Cost.

A	B	C	D	E	A	B	C	D	E
1 %	And 0% off	= 1% off	99	1 01	60 %	And 0% off	=60% off	40	150
2 "	0 "	= 2 "	98	2 04	60 "	2½"	=61 "	39	156 41
3 "	0 "	= 3 "	97	3 09	60 "	5 "	=62 "	38	163 16
4 "	0 "	= 4 "	96	4 17	60 "	7½"	=63 "	37	170 27
5 "	0 "	= 5 "	95	5 26	60 "	10 "	=64 "	36	177 78
6 "	0 "	= 6 "	94	6 38	60 "	12½"	=65 "	35	185 71
7 "	0 "	= 7 "	93	7 53	60 "	15 "	=66 "	34	194 12
8 "	0 "	= 8 "	92	8 70	60 "	17½"	=67 "	33	203 03
10 "	0 "	=10 "	90	11 11	60 "	20 "	=68 "	32	212 50
10 "	2½"	=12¼"	87¾	13 96	60 "	22½"	=69 "	31	222 58
10 "	5 "	=14½"	85½	16 96	60 "	25 "	=70 "	30	233 33
12½"	0 "	=12½"	87½	14 29	60 "	27½"	=71 "	29	244 83
12½"	2½"	=14⅔"	85⅓	*17 19	60 "	30 "	=72 "	28	257 14
12½"	5 "	=16⅞"	83⅛	20 30"	60 "	33⅓"	=73⅓"	26	275
15 "	0 "	=15 "	85	17 65"	60 "	35 "	=74 "	26⅔	284 62
15 "	2½"	=17⅛"	82⅞	20 66"	60 "	37½"	=75 "	25	300
15 "	5 "	=19¼"	80¾	23 84"	60 "	40 "	=76 "	24	316 67
15 "	10 "	=23½"	76½	30 72"	60 "	42½"	=77 "	23	334 78
16⅔"	0 "	=16⅔"	83⅓	20 "	60 "	45 "	=78 "	22	354 55
16⅔"	2½"	=18¾"	81¼	23 08"	60 "	47½"	=79 "	21	376 19
16⅔"	5 "	=20⅚"	79⅙	26 32"	60 "	50 "	=80 "	20	400
16⅔"	10 "	=25 "	75	33 33"	66⅔"	0 "	=66⅔"	33⅓	200
20 "	0 "	=20 "	80	25 "	66⅔"	5 "	=68⅓"	31⅓	215 79
20 "	2½"	=22 "	78	28 21"	66⅔"	10 "	=70 "	30	233 33
20 "	5 "	=24 "	76	31 58"	66⅔"	20 "	=73⅓"	26⅔	275
20 "	10 "	=28 "	72	38 89"	66⅔"	25 "	=75 "	25	300
20 "	15 "	=32 "	68	47 06"	66⅔"	33⅓"	=77 7/9"	22 2/9	350
25 "	0 "	=25 "	75	33 33"	66⅔"	40 "	=80 "	20	400
25 "	2½"	=26⅞"	73⅛	36 75"	66⅔"	50 "	=83⅓"	16⅔	500
25 "	5 "	=28¾"	71¼	40 35"	70 "	0 "	=70 "	30	233 33
25 "	10 "	=32½"	67½	48 15"	70 "	5 "	=71½"	28½	250 88
25 "	20 "	=40 "	60	66 67"	70 "	10 "	=73 "	27	270 37
30 "	0 "	=30 "	70	42 86"	70 "	20 "	=76 "	24	316 67
30 "	2½"	=31¾"	68¼	46 52"	70 "	25 "	=77½"	22½	344 44
30 "	5 "	=33½"	66½	50 38"	70 "	30 "	=79 "	21	376 19
30 "	10 "	=37 "	63	58 73"	70 "	33⅓"	=80 "	20	400
30 "	20 "	=44 "	56	78 57"	70 "	40 "	=82 "	18	455 56
33⅓"	0 "	=33⅓"	66⅔	50 "	70 "	50 "	=85 "	15	566 67
33⅓"	2½"	=35 "	65	53 85"	75 "	0 "	=75 "	25	300
33⅓"	5 "	=36⅔"	63⅓	57 89"	75 "	5 "	=76¼"	23¾	321 05
33⅓"	10 "	=40 "	60	66 67"	75 "	10 "	=77½"	22½	344 44
33⅓"	20 "	=46⅔"	53⅓	87 50"	75 "	20 "	=80 "	20	400
33⅓"	25 "	=50 "	50	100 "	75 "	25 "	=81¼"	18¾	433 33
35 "	0 "	=35 "	65	53 85"	75 "	30 "	=82½"	17½	471 43
37½"	0 "	=37½"	62½	60 "	75 "	33⅓"	=83⅓"	16⅔	500
40 "	0 "	=40 "	60	66 67"	75 "	40 "	=85 "	15	566 67
40 "	2½"	=41½"	58½	70 94"	75 "	50 "	=87½"	12½	700
40 "	5 "	=43 "	57	75 44"	80 "	0 "	=80 "	20	400
40 "	10 "	=46 "	54	85 19"	80 "	5 "	=81 "	19	426 32
40 "	15 "	=49 "	51	96 08"	80 "	10 "	=82 "	18	455 56
40 "	20 "	=52 "	48	108 33"	80 "	20 "	=84 "	16	525
40 "	25 "	=55 "	45	122 22"	80 "	25 "	=85 "	15	566 67
40 "	30 "	=58 "	42	138 10"	80 "	30 "	=86 "	14	614 29
40 "	33⅓"	=60 "	40	150 "	80 "	40 "	=88 "	12	733 33
45 "	0 "	=45 "	55	81 82"	80 "	50 "	=90 "	10	900
40 "	0 "	=50 "	50	100 "	80 "	60 "	=92 "	08	1150
50 "	2½"	=51¼"	48¾	105 13"	90 "	0 "	=90 "	10	900
50 "	5 "	=52½"	47½	110 53"	90 "	10 "	=91 "	09	1011 11
50 "	10 "	=55 "	45	122 22"	90 "	20 "	=92 "	08	1150
50 "	15 "	=57½"	42½	135 29"	90 "	30 "	=93 "	07	1328 57
50 "	20 "	=60 "	40	150 "	90 "	40 "	=94 "	06	1566 67
50 "	25 "	=62½"	37½	166 67"	90 "	50 "	=95 "	05	1900
50 "	30 "	=65 "	35	185 71"	90 "	60 "	=96 "	04	2400
50 "	33⅓"	=66⅔"	33⅓	200 "	90 "	70 "	=97 "	03	3233 33
50 "	40 "	=70 "	30	233 33"	90 "	80 "	=98 "	02	4900
55 "	0 "	=55 "	45	122 22"	90 "	90 "	=99 "	01	9900

Cents on the Dollar.

Per Cent Profit (see last col.)

Col. E, shows the % made on Cost, when goods are bought at one or more Discounts from List price, and sold at List price. D, shows No. of Cents paid on $.

The whole Discount is shown in Col. C, when two (A and B) are given. Thus 40 % off (A) and 10% off remainder (B), = 46% off (C); which = 54c on the $ (D,)&c (See Art. 194). The Rules and Principles of Trade Discount are clearly set forth in Arts. 190 to 193.

TABLE Aiding DEALERS, MANUFACTURERS—Fixing Prices, Profits, Discounts.

For Retail Trade			For Wholesale Trade			Manufacturers, Jobbers		
If you Add to Cost Price	And deduct off Retail Price	Profit on Cost will be	If you Buy (of List) at	And Sell (same List) at	Profit on Cost will be	In order to give Trade	And realize on Cost	List Price must be
10 %	2 1/2%	7 1/4%	10% off	2 1/2% off	8 1/3 %	10% off	10 %	1 2/9
10 “	5 “	4 1/2 “	10 “	5 “	5 5/9 “	10 “	20 “	1 1/3
12 1/2 “	5 “	6 7/8 “	12 1/2 “	5 “	8 4/7 “	12 1/2 “	20 “	*1 3/8
15 “	5 “	9 1/4 “	15 “	5 “	*11 3/4 “	15 “	20 “	*1 5/8
16 2/3 “	5 “	10 5/8 “	16 2/3 “	5 “	14 3/4 “	16 2/3 “	20 “	*1 4/9
20 “	2 1/2 “	17 “	20 “	5 “	18 3/4 “	20 “	20 “	1 1/2
20 “	5 “	14 “	20 “	10 “	12 1/2 “	20 “	30 “	1 5/8
20 “	10 “	8 “	20 “	12 1/2 “	9 3/8 “	20 “	40 “	1 3/4
20 “	12 1/2 “	5 “	20 “	15 “	6 1/4 “	20 “	50 “	1 7/8
25 “	2 1/2 “	21 7/8	25 “	5 “	26 2/3 “	25 “	20 “	1 3/5 “
25 “	5 “	18 3/4 “	25 “	10 “	20 “	25 “	30 “	*1 3/4 “
25 “	10 “	12 1/2 “	25 “	15 “	13 1/3 “	25 “	40 “	*1 7/8 “
25 “	15 “	6 1/4 “	25 “	20 “	6 2/3 “	25 “	50 “	2 “
30 “	2 1/2 “	26 3/4 “	30 “	10 “	28 4/7 “	30 “	20 “	1 5/7 “
30 “	5 “	23 1/2 “	30 “	15 “	21 3/7 “	30 “	30 “	1 6/7 “
30 “	10 “	17 “	30 “	20 “	14 2/7 “	30 “	40 “	2 “
30 “	15 “	10 1/2 “	30 “	25 “	7 1/7 “	30 “	50 “	2 1/7 “
33 1/3 “	2 1/2 “	30 “	33 1/3 “	10 “	35 “	33 1/3 “	20 “	1 4/5 “
33 1/3 “	5 “	26 2/3 “	33 1/3 “	15 “	27 1/2 “	33 1/3 “	33 1/3 “	2 “
33 1/3 “	10 “	20 “	33 1/3 “	20 “	20 “	33 1/3 “	40 “	2 1/10 “
33 1/3 “	15 “	13 1/3 “	33 1/3 “	25 “	12 1/2 “	33 1/3 “	50 “	2 1/4 “
33 1/3 “	20 “	6 2/3 “	33 1/3 “	30 “	5 “	33 1/3 “	60 “	2 2/5 “
40 “	2 1/2 “	36 1/2 “	40 “	10 “	50 “	40 “	20 “	2 “
40 “	5 “	33 “	40 “	15 “	41 2/3 “	40 “	30 “	2 1/6 “
40 “	10 “	26 “	40 “	20 “	33 1/3 “	40 “	40 “	2 1/3 “
40 “	15 “	19 “	40 “	25 “	25 “	40 “	50 “	2 1/2 “
40 “	20 “	12 “	40 “	30 “	16 2/3 “	40 “	60 “	2 2/3 “
40 “	25 “	5 “	40 “	33 1/8 “	11 1/9 “	40 “	80 “	3 “
50 “	5 “	42 1/2 “	50 “	10 “	80 “	50 “	33 1/3 “	2 8/3 “
50 “	10 “	35 “	50 “	20 “	60 “	50 “	40 “	2 4/5 “
50 “	15 “	27 1/2 “	50 “	25 “	50 “	50 “	50 “	3 “
50 “	20 “	20 “	50 “	30 “	40 “	50 “	60 “	3 1/5 “
50 “	25 “	12 1/2 “	50 “	33 1/3 “	33 1/3 “	50 “	80 “	3 3/5 “
50 “	30 “	5 “	50 “	40 “	20 “	50 “	100 “	4 “
60 “	5 “	52 “	60 “	20 “	100 “	60 “	33 1/3 “	3 1/3 “
60 “	10 “	44 “	60 “	25 “	87 1/2 “	60 “	40 “	3 1/2 “
60 “	15 “	36 “	60 “	30 “	75 “	60 “	50 “	3 3/4 “
60 “	20 “	28 “	60 “	33 1/3 “	66 2/3 “	60 “	60 “	4 “
60 “	25 “	20 “	60 “	40 “	50 “	60 “	70 “	4 1/4 “
60 “	30 “	12 “	60 “	45 “	37 1/2 “	60 “	80 “	4 1/2 “
60 “	33 1/3 “	6 2/3 “	60 “	50 “	25 “	60 “	100 “	5 “
66 2/3 “	10 “	50 “	66 2/3 “	20 “	140 “	66 2/3 “	33 1/3 “	4 “
66 2/3 “	15 “	41 2/3 “	66 2/3 “	25 “	125 “	66 2/3 “	40 “	4 1/5 “
66 2/3 “	20 “	33 1/3 “	66 2/3 “	33 1/3 “	100 “	66 2/3 “	50 “	4 1/2 “
66 2/3 “	25 “	25 “	66 2/3 “	40 “	80 “	66 2/3 “	60 “	4 4/5 “
66 2/3 “	30 “	16 2/3 “	66 2/3 “	50 “	50 “	66 2/3 “	80 “	5 2/5 “
66 2/3 “	33 1/3 “	11 1/9 “	66 2/3 “	60 “	20 “	66 2/3 “	100 “	6 “
70 “	10 “	53 “	70 “	25 “	150 “	70 “	33 1/3 “	4 4/9 “
70 “	15 “	44 1/2 “	70 “	30 “	133 1/3 “	70 “	40 “	4 2/3 “
70 “	20 “	36 “	70 “	33 1/3 “	122 2/9 “	70 “	50 “	5 “
70 “	25 “	27 1/2 “	70 “	40 “	100 “	70 “	60 “	5 1/3 “
70 “	30 “	19 “	70 “	50 “	66 2/3 “	70 “	80 “	6 “
70 “	33 1/3 “	13 1/3 “	70 “	60 “	33 1/3 “	70 “	100 “	6 2/3 “
75 “	10 “	57 1/2 “	75 “	30 “	180 “	75 “	33 1/3 “	5 1/3 “
75 “	15 “	48 3/4 “	75 “	40 “	140 “	75 “	40 “	5 3/5 “
75 “	20 “	40 “	75 “	50 “	100 “	75 “	50 “	6 “
75 “	25 “	31 1/4 “	75 “	60 “	60 “	75 “	60 “	6 2/5 “
75 “	30 “	22 1/2 “	75 “	66 2/3 “	33 1/3 “	75 “	80 “	7 1/5 “
75 “	33 1/3 “	16 2/3 “	75 “	70 “	20 “	75 “	100 “	8 “
80 “	10 “	62 “	80 “	30 “	250 “	80 “	33 1/3 “	6 2/3 “
80 “	15 “	53 “	80 “	40 “	200 “	80 “	40 “	7 “
80 “	20 “	44 “	80 “	50 “	150 “	80 “	50 “	7 1/2 “
80 “	25 “	35 “	80 “	60 “	100 “	80 “	60 “	8 “
80 “	30 “	26 “	80 “	70 “	50 “	80 “	80 “	9 “
80 “	33 1/3 “	20 “	80 “	75 “	25 “	80 “	100 “	10 “

Times the Cost.

(A). If you mark goods to make 40% profit (col.1), then sell at a discount of 20% from marking price (c.2), your profit will be 12% on cost (c.3). (Art. 195).

(B). If you buy at 50% off (col. 1), and sell to the Trade or Agents at 40% off same List (col.2), your profit will be 20% on cost (col.3) (See Rule, Art. 196).

(C.) In order to give the Trade or Agents 50% off (col. 1), and still make 100% profit on the cost (c.2), the List price must be 4 times the cost (c.3). (Art. 197).

These Tables will save Buyers and Sellers many abstruse Calculations.

PERPETUAL CALENDAR

GOOD FOR THREE CENTURIES

1800	1801	1802	1803	.....	**1804**	1805
1806	1807	.....	**1808**	1809	1810	1811
.....	**1812**	1813	1814	1815	.....	**1816**
1817	1818	1819	.....	**1820**	1821	1822
1823	.....	**1824**	1825	1826	1827	.....
1828	1829	1830	1831	.....	**1832**	1833
1834	1835	.....	**1836**	1837	1838	1839
.....	**1840**	1841	1842	1843	.....	**1844**
1845	1846	1847	.....	**1848**	1849	1850
1851	.....	**1852**	1853	1854	1855	.....
1856	1857	1858	1859	.....	**1860**	1861
1862	1863	.....	**1864**	1865	1866	1867
.....	**1868**	1869	1870	1871	.....	**1872**
1873	1874	1875	.....	**1876**	1877	1878
1879	.....	**1880**	1881	1882	1883	.....
1884	1885	1886	1887	.....	**1888**	1889
1890	1891	.....	**1892**	1893	1894	1895
.....	**1896**	1897	1898	1899	1900	1901
1902	1903	.....	**1904**	1905	1906	1907
.....	**1908**	1909	1910	1911	.....	**1912**
1913	1914	1915	.....	**1916**	1917	1918
1919	.....	**1920**	1921	1922	1923	.....
1924	1925	1926	1927	.....	**1928**	1929
1930	1931	.....	**1932**	1933	1934	1935
.....	**1936**	1937	1938	1939	.....	**1940**
Ja 3^{2}	Ja 4^{3}	Ja 5^{4}	Ja 6^{5}	Ja 7^{6}	Ja 1^{7}	Ja 2^{1}
Fe 6^{5}	Fe 7^{6}	Fe 1^{7}	Fe 2^{1}	Fe 3^{2}	Fe 4^{3}	Fe 5^{4}
Ma **6**	Ma **7**	Ma **1**	Ma **2**	Ma **3**	Ma **4**	Ma **5**
Ap **2**	Ap **3**	Ap **4**	Ap **5**	Ap **6**	Ap **7**	Ap **1**
My **4**	My **5**	My **6**	My **7**	My **1**	My **2**	My **3**
Ju **7**	Ju **1**	Ju **2**	Ju **3**	Ju **4**	Ju **5**	Ju **6**
Jy **2**	Jy **3**	Jy **4**	Jy **5**	Jy **6**	Jy **7**	Jy **1**
Au **5**	Au **6**	Au **7**	Au **1**	Au **2**	Au **3**	Au **4**
Se **1**	Se **2**	Se **3**	Se **4**	Se **5**	Se **6**	Se **7**
Oc **3**	Oc **4**	Oc **5**	Oc **6**	Oc **7**	Oc **1**	Oc **2**
No **6**	No **7**	No **1**	No **2**	No **3**	No **4**	No **5**
De **1**	De **2**	De **3**	De **4**	De **5**	De **6**	De **7**

1st Clndr	2nd Clndr	3rd Clndr	4th Clndr	5th Clndr	6th Clndr	7th Clndr
1 Mo	1 Tu	1 We	1 Th	1 Fr	1 Sa	1 **Su**
2 Tu	2 We	2 Th	2 Fr	2 Sa	2 **Su**	2 Mo
3 We	3 Th	3 Fr	3 Sa	3 **Su**	3 Mo	3 Tu
4 Th	4 Fr	4 Sa	4 **Su**	4 Mo	4 Tu	4 We
5 Fr	5 Sa	5 **Su**	5 Mo	5 Tu	5 We	5 Th
6 Sa	6 **Su**	6 Mo	6 Tu	6 We	6 Th	6 Fr
7 **Su**	7 Mo	7 Tu	7 We	7 Th	7 Fr	7 Sa
8 Mo	8 Tu	8 We	8 Th	8 Fr	8 Sa	8 **Su**
9 Tu	9 We	9 Th	9 Fr	9 Sa	9 **Su**	9 Mo
10 We	10 Th	10 Fr	10 Sa	10 **Su**	10 Mo	10 Tu
11 Th	11 Fr	11 Sa	11 **Su**	11 Mo	11 Tu	11 We
12 Fr	12 Sa	12 **Su**	12 Mo	12 Tu	12 We	12 Th
13 Sa	13 **Su**	13 Mo	13 Tu	13 We	13 Th	13 Fr
14 **Su**	14 Mo	14 Tu	14 We	14 Th	14 Fr	14 Sa
15 Mo	15 Tu	15 We	15 Th	15 Fr	15 Sa	15 **Su**
16 Tu	16 We	16 Th	16 Fr	16 Sa	16 **Su**	16 Mo
17 We	17 Th	17 Fr	17 Sa	17 **Su**	17 Mo	17 Tu
18 Th	18 Fr	18 Sa	18 **Su**	18 Mo	18 Tu	18 We
19 Fr	19 Sa	19 **Su**	19 Mo	19 Tu	19 We	19 Th
20 Sa	20 **Su**	20 Mo	20 Tu	20 We	20 Th	20 Fr
21 **Su**	21 Mo	21 Tu	21 We	21 Th	21 Fr	21 Sa
22 Mo	22 Tu	22 We	22 Th	22 Fr	22 Sa	22 **Su**
23 Tu	23 We	23 Th	23 Fr	23 Sa	23 **Su**	23 Mo
24 We	24 Th	24 Fr	24 Sa	24 **Su**	24 Mo	24 Tu
25 Th	25 Fr	25 Sa	25 **Su**	25 Mo	25 Tu	25 We
26 Fr	26 Sa	26 **Su**	26 Mo	26 Tu	26 We	26 Th
27 Sa	27 **Su**	27 Mo	27 Tu	27 We	27 Th	27 Fr
28 **Su**	28 Mo	28 Tu	28 We	28 Th	28 Fr	28 Sa
29 Mo	29 Tu	29 We	29 Th	29 Fr	29 Sa	29 **Su**
30 Tu	30 We	30 Th	30 Fr	30 Sa	30 **Su**	30 Mo
31 We	31 Th	31 Fr	31 Sa	31 **Su**	31 Mo	31 Tu

For Finding the Day of the Week for Any Date from 1800 to 1940.

To find the right Calendar—for July 1876, for instance; **look for 1876, run down that column to July, the figure 6 there refers to the 6th Calendar**, which shows that the 1st of July 1876 occurred on Saturday; the 4th on Tuesday, &c.

Note—In **Leap Years**, use the **small** figures for **Jan. and Feb.**

For any Date in the 18th Century, shift two days forward; and for the 20th, two days backward from the corresponding Day in the 19th. Thus, we find that in 1876, July 4, occurred on Tues.; hence, in 1776, it must have occurred on Thurs.—two days forward from Tues.; and in 1976, it will fall on Sun.—two days backward from Tues. (Art. 360.)

It is quite interesting to know on what Day births, deaths and other notable events occurred.

On what Day were You born?

The **Table** on the right shows on what Day of the month, in Mar., or Apr., **Easter Sundays** fall from the year 1801 to 1950.

The Council of Nice, in A. D., 325, decreed that Easter should be celebrated, always on the first Sunday after the Full Moon next after the Spring Equinox. Hence, Easter can come as early as March 22, as in 1818; and as late as April 25, as in 1886.

EASTER SUNDAYS

1801	A 5	1851	A 20	1901	A 7
1802	A 18	1852	A 11	1902	M30
1803	A 10	1853	M27	1903	A 12
1804	A 1	1854	A 16	1904	A 3
1805	A 14	1855	A 8	1905	A 23
1806	A 6	1856	M23	1906	A 15
1807	M29	1857	A 12	1907	M31
1808	A 17	1858	A 4	1908	A 19
1809	A 2	1859	A 24	1909	A 11
1810	A 22	1860	A 8	1910	M27
1811	A 14	1861	M31	1911	A 16
1812	M29	1862	A 20	1912	A 7
1813	A 18	1863	A 5	1913	M23
1814	A 10	1864	M27	1914	A 12
1815	M26	1865	A 16	1915	A 4
1816	A 14	1866	A 1	1916	A 23
1817	A 6	1867	A 21	1917	A 8
1818	M22	1868	A 12	1918	M31
1819	A 11	1869	M28	1919	A 20
1820	A 2	1870	A 17	1920	A 4
1821	A 22	1871	A 9	1921	M27
1822	A 7	1872	M31	1922	A 16
1823	M30	1873	A 13	1923	A 1
1824	A 18	1874	A 5	1924	A 20
1825	A 3	1875	M28	1925	A 12
1826	M26	1876	A 16	1926	A 4
1827	A 15	1877	A 1	1927	A 17
1828	A 6	1878	A 21	1928	A 8
1829	A 19	1879	A 13	1929	M31
1830	A 11	1880	M28	1930	A 20
1831	A 3	1881	A 17	1931	A 6
1832	A 22	1882	A 9	1932	M27
1833	A 7	1883	M25	1933	A 16
1834	M30	1884	A 13	1934	A 1
1835	A 19	1885	A 5	1935	A 21
1836	A 3	1886	A 25	1936	A 12
1837	M26	1887	A 10	1937	M28
1838	A 15	1888	A 1	1938	A 17
1839	M31	1889	A 21	1939	A 9
1840	A 19	1890	A 6	1940	M24
1841	A 11	1891	M29	1941	A 13
1842	M27	1892	A 17	1942	A 6
1843	A 16	1893	A 2	1943	A 25
1844	A 7	1894	M25	1944	A 9
1845	M23	1895	A 14	1945	A 1
1845	A 12	1896	A 5	1946	A 21
1847	A 4	1897	A 18	1947	A 6
1848	A 23	1898	A 10	1948	M28
1849	A 8	1899	A 2	1949	A 17
1850	M31	1900	A 15	1950	A 9

Arco Wand Vacuum Cleaner.

Wiring Chart Should Be Sent With Each Machine.

All that is required of the trade in the matter of electric installation is to obtain from the local electric power station the information as to whether direct or alternating current is to be used. If it is direct current, ascertain the voltage; or if it is alternating current, the voltage, phase and cycles. When this information is sent to us, a correct wiring chart to apply exactly to the conditions is sent with the vacuum cleaner, making it a very easy matter for the electrician to make proper wiring connections. The wiring charts here inserted show the completeness of the information we furnish with each machine.

Wiring Diagrams of Alternating Current Single-Phase Installations With Remote Control for ½, ¾, 1½ and 2 Horse Power Motors.

Note. Motors are installed without starting box. Direct current, motors are series wound with enough shunt winding to prevent racing under no load conditions.

Note A. Switches No. 1 and No. 2 are three-way snap switches. A control circuit of this nature consists primarily of two (2) three-way switches and if more control points are needed, four-way switches will be connected between the two three-ways, i. e., if four control points are wanted two (2) four-way switches will be connected between two (2) three-way switches.

Note B. Switch No. 1 must be located not to exceed 4 feet from vacuum cleaner relief valve so that both can be reached at the same time.

Note C. If metal conduit is used draw all three control wires into one conduit.

Wiring Diagrams of Alternating Current Single-Phase Installations With Remote Control for ½ and ¾ Horse Power Motors.

Note. Motors are installed without starting box. Direct current, motors are series wound with enough shunt winding to prevent racing under no load conditions.

Be careful to connect proper switch terminals to motor and line leads. Failure to do this will result in short circuiting line if two or more switches are closed at one time. One of these switches must be located not to exceed 4 feet from vacuum cleaner re-

lief valve so that both can be reached at the same time. If motor is connected for 220 volts, ten (10) ampere double pole flush switches to be used. If motor is connected for 110 volts, twenty (20) ampere double pole rotary surface switches to be used.

Sizes of Pipe.

With Nos. 460, 461 and 462 Arco Wand Vacuum Cleaners, 1½-inch pipe can be used where distance from machine to most remote inlet coupling does not exceed 60 ft.; 2-inch pipe can be used where distance from machine to most remote inlet coupling, with No. 461, does not exceed ?50 ft., and with No. 462 does not exceed 350 ft. In such runs of 2-inch piping, 1½-inch pipe can be used for 60 ft. from remote inlet couplings toward the machine, using 2-inch pipe for remainder of distance. Thus, risers in any building less than 60 ft. in height can be made of 1½-inch pipe, using 2-inch pipe for horizontal mains in basement. The exhaust pipe for each of these machines should be 2-inch pipe.

Installing Inlet Couplings.

First. After applying lead or pipe-joint paste to the male thread of the inlet coupling bushing, screw it into the opening of the drainage fitting as far as possible, using the Arco Wand wrench.

Inlet Coupling in Place.

Second. After applying lead or pipe-joint paste to the male thread of the inlet coupling, start it into the thread of the inlet coupling bushing, turning it by hand. Then insert the wrench into the opening of the inlet coupling and turn until the flange is drawn up snugly against the baseboard, stopping with the cover hinge at the top.

Use Good Lead or Pipe-Joint Paste.

In the installation of piping for vacuum cleaning, always apply lead or pipe-joint paste to the male threads of pipe and fittings. If applied in this way when the threads are made up, all surplus lead or paste will be forced to the outside of the fittings and pipe, leaving the interior free from such substances.

Never apply lead or paste to female threads.

Typical riser, concealed in partition, one inlet coupling to be located in baseboard in each story.

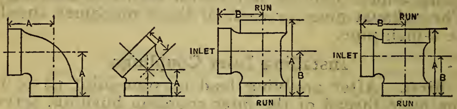
Section of Cleaner-Main.

When it is necessary to drop a pipe for an inlet coupling located below the cleaner-main, always make the connection from the side of the cleaner-main, and never from the bottom—as bottom connection would fill with dirt.

Drainage Fittings, Cast Iron, Screwed for Wrought Iron Pipe.

These fittings are made with a shoulder, and are the same size inside diameter as pipe.

The pipe screws in up to the shoulder, making a continuous passage, leaving no pockets for the solid matter to lodge in, thus preventing choking up of the pipe.



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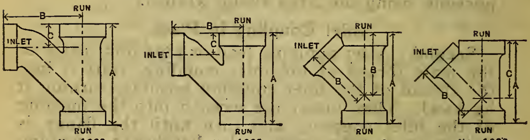

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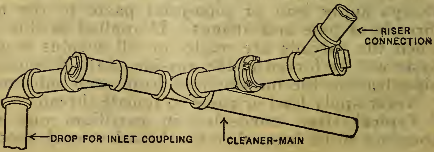
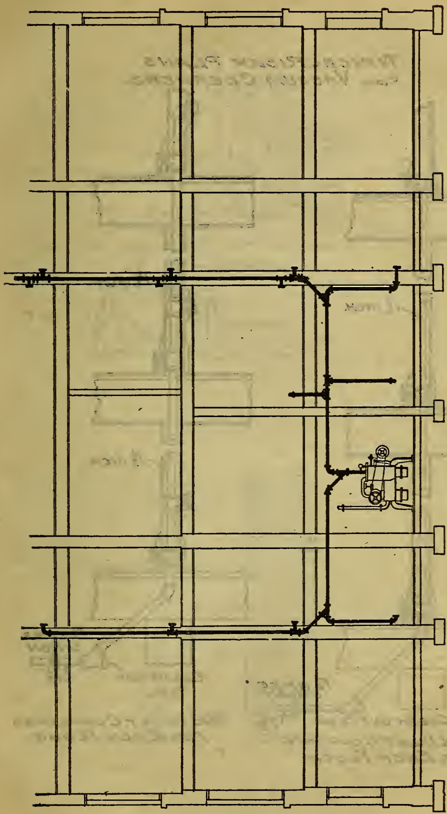
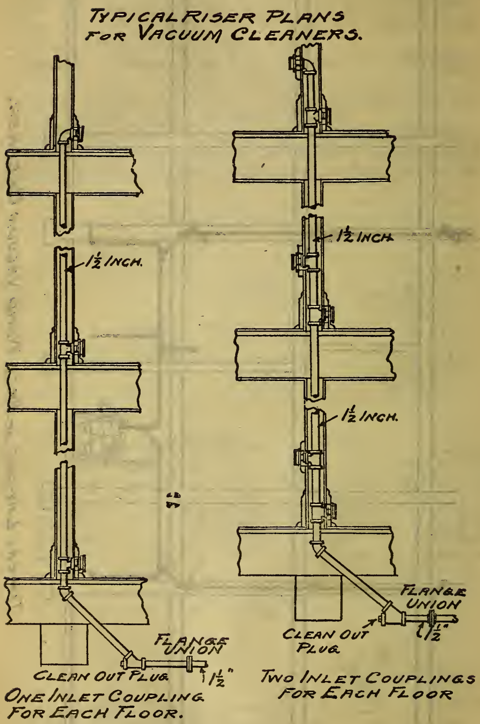
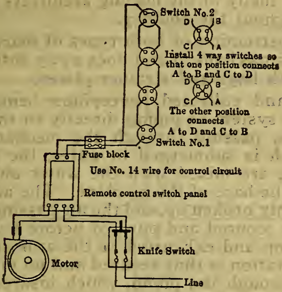


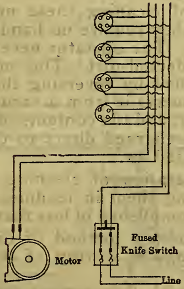


TYPICAL LAY-OUT OF ARCO WAND VACUUM CLEANER.



TYPICAL RISER PLANS
FOR VACUUM CLEANERS.
1½ INCH.
1½ INCH.
1½ INCH.
FLANGE UNION
CLEAN OUT PLUG
1½"
ONE INLET COUPLING
FOR EACH FLOOR.
FLANGE UNION
CLEAN OUT PLUG
1½"
TWO INLET COUPLINGS
FOR EACH FLOOR


Switch No.2
D B
C A
Install 4 way switches so that one position connects A to B and C to D
D B
C A
The other position connects A to D and C to B
Switch No.1
Fuse block
Use No. 14 wire for control circuit
Remote control switch panel
Knife Switch
Motor
Line


Fused Knife Switch
Motor
Line

The American Rotary Valve Company, Chicago, are manufacturers of both the rotary and reciprocating type vacuum cleaning machines, in which are embodied a number of novel features that have been endorsed by many of the leading architects and engineers throughout the country.

In the construction of both types of machines, the separation is mechanical and does away entirely with screens, cloth bags and strainer plates.

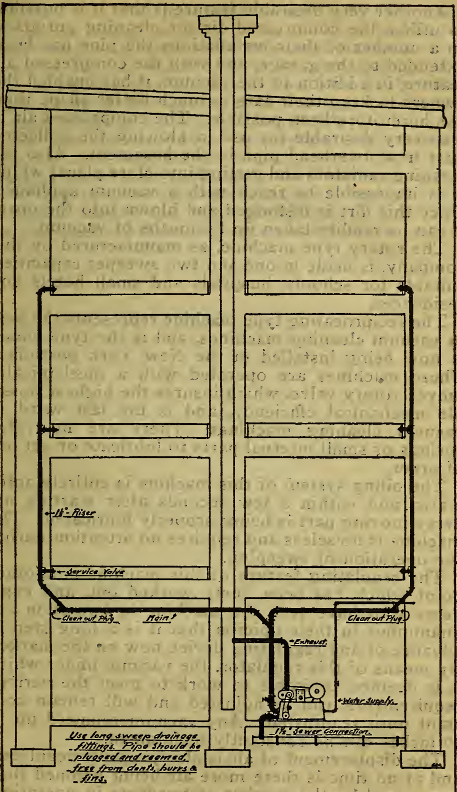
The air and collected sweepings being carried through the system of piping directly to the base of the machine, passing through the mechanical separator, which is submerged in water, the dirt, dust and bacteria are mixed with the water and held in solution in the base of the machine. The air bubbles are thoroughly broken up, and the air passing through the water is scoured and purified before being taken into the pump and exhausted to the atmosphere. A perfect separation is thus secured and no dirt or dust is carried through the pump, which insures its long life. Screens, cloth bags and strainer plates have a strong tendency to become heavily coated or clogged with collected dirt and dust. The entire elimination of such devices in these machines insures the highest constant efficiency.

The method of cleaning these machines is also mechanical and they require no hand cleaning whatever at any time. The operator never comes in contact with the collected dirt. This method of cleaning is accomplished by reversing the action of the pump, which converts it from a vacuum producer to an air compressor, and the contents of the base, when necessary, are discharged direct to the sewer under force of compressed air.

The entire operation of cleaning out these machines and putting them in readiness for operation on vacuum is accomplished in less than three minutes.

The highly sanitary method of disposing of the collected sweepings is worthy of the highest consideration.

Contrast this with the systems which necessitate the disposal of the dirt and bacteria in a manner which not only exposes the one who cleans the machine, but the entire neighborhood, to possible contagion.



Piping Layout
Vacuum Cleaning System.

Another very desirable feature is that it is possible to utilize the compressed air for cleaning purposes. In a number of their installations the pipe has been extended to the garage, and with the compressed air feature, in addition to the vacuum, it has enabled the owners to keep their cars in much better shape than has heretofore been possible. The compressed air is also very desirable for use in blowing the collected dust from overhead pipe in the basement. Also for cleaning radiators and getting into close places which it is impossible to reach with a vacuum appliance. Once this dirt is dislodged and blown into the open, it can be readily taken up by means of vacuum.

The rotary type machine, as manufactured by this company, is made in one and two sweeper capacities, suitable for schools, hospitals and small hotels and residences.

The reciprocating type machine represents the best in vacuum cleaning machines, and is the type which is now being installed in the New York postoffice. These machines are operated with a mechanically moved rotary valve, which insures the highest possible mechanical efficiency, and is the last word in vacuum cleaning machines. There are no valve springs or small internal parts to lubricate or get out of order.

The oiling system of this machine is entirely automatic, and within a few seconds after starting up, every moving part is being properly lubricated. The machine is noiseless and requires no attention during the operation of sweeping.

The regulating feature of this machine is another point which has been finely worked out, and engineers who have seen the machine in operation are unanimous in their opinion that it is a long step in advance of any regulating device now on the market. By means of this regulator, the vacuum under which it is deemed advisable to work to meet the various requirements, can be adjusted and will remain constant until readjusted. Any vacuum required up to 20 inches can be constantly maintained.

The displacement of air is also properly regulated, and at no time is there more air being pumped than is required by the number of sweepers in operation, the reduction being proportionate, and results in a big saving in consumption of power when less sweepers than the capacity of the machine are in operation.

These reciprocating type vacuum cleaning machines are being installed in large office buildings, public buildings, hotels, hospitals, mills, factories and theaters, and are manufactured in capacities to take care of buildings of any size. The New York post-office being a fine example, this being the largest vacuum cleaning machine in the world.

We are showing here two systems of vacuum cleaning machines, the dry and the wet. These two systems have been thoroughly tried out and found to be the best that has been manufactured and the best that money can buy. Architects all over the country endorse these two types of machines.

Mechanical Refrigeration

Mechanical refrigeration is the process of reducing and keeping the temperature of a body or substance below the temperature of the atmosphere without the use of ice. In order to reduce such temperature it is necessary to employ a medium of lower temperature, which will absorb the heat. Liquids having a low boiling point are used as refrigerants. Carbonic anhydride (carbonic acid) and ammonia are used as refrigerants.

Carbonic anhydride evaporates at the low temperature of 124 degrees below zero Fahr. under atmospheric pressure and during evaporation absorbs from its surroundings a quantity of heat corresponding to its latent heat of evaporation. In other words, while water boils at 212 degrees Fahr. under atmospheric pressure, and about 250 degrees at fifteen pounds pressure; liquid carbonic anhydride boils at 124 degrees below zero Fahr. under atmospheric pressure and at 30 degrees Fahr. under a pressure of 34 atmospheres. Ammonia boils at 28 degrees Fahr.

The boiling point of water being far above the atmospheric temperature, heat must be applied to bring it to the boiling temperature. The boiling point of liquid carbonic anhydride and ammonia being very much lower than the temperature of the atmosphere, they absorb from their surroundings the necessary heat to cause them to boil or evaporate.

Refrigeration is produced by the ebullition of the refrigerant which is circulated through the cooling coils and returned to the refrigerating machine.

The cycle of operation is the compression, liquefaction and evaporation of the carbonic anhydride or ammonia.

The refrigerating plant comprises three parts.

1. A compressor in which the gas is compressed.
2. A condenser in which the compressed warm gas imparts its heat to cold water and liquefies.
3. Expansion coils in which the liquid re-expands into its original gaseous state, thereby absorbing heat and performing the refrigerating work.

In order to make the operation continuous the three parts are connected; the charge of gas originally put into the machine being used over and over again going progressively through the process of compression, condensation and evaporation. Thus

only a small quantity of gas is required to replace any losses.

The compressor draws the gas from the expansion coils, compressing it to the liquefying pressure (which pressure depends upon the temperature of the cooling water in the condenser). The compressed gas is discharged into the condenser where it imparts its heat to the water in the condenser and becomes a liquid. This liquid is then returned to the expansion or cooling coils, expanding through same and thereby absorbing heat.

The surface of the cooling coils is so proportioned that all of the liquid evaporates as it passes through same. From there the gas again returns to the compressor to resume the cycle of operation. The pressure of the gas in the coils is controlled by means of a valve.

Direct Expansion System.

In the direct expansion system extra heavy wrought iron pipe coils are placed in the rooms to be cooled, either on ceiling, walls or in lofts built for this purpose. Connections are made between the coils and liquid receiver at outlet of condenser. An expansion or regulating valve is placed between the small liquid pipe and large expansion coils. The liquid is fed through the expansion valve and allowed to expand through the coil to a gaseous state. During its evaporation the carbonic anhydride or ammonia absorb heat from the surrounding atmosphere and then return to the compressor.

For general cold storage plants, breweries, packing houses, candy factories and similar plants the direct expansion system is preferable. It is the simplest system, requires less machinery, is more efficient, needs less attention and for these reasons is used where possible. With carbonic anhydride the direct expansion system can be used in many places where it would not be advisable with ammonia. In case of a leak in the expansion coils with the carbonic anhydride system no damage can result, while with the ammonia system the result might be disastrous.

Brine System.

The brine system is an indirect method of refrigeration; the carbonic anhydride or ammonia do not evaporate in coils placed in the rooms to be cooled, but instead evaporate through coils placed in an insulated steel tank, or through double pipe brine coolers.

Brine is made by dissolving calcium chloride in water; in some instances common salt (sodium chloride) is used. This brine is cooled by circulating it through a double pipe cooler or tank equipped with carbonic anhydride or ammonia coils and then pumped through the coils in the different refrigerators and rooms. The brine absorbs heat in passing through the coils and upon returning to the cooler it imparts this heat to the carbonic anhydride or ammonia.

In plants with a large number of small refrigerators, where the pipe runs are long, it is cheaper to install the brine system, as brine piping costs less than direct expansion piping. When the refrigerating machine is not operated at night and even temperatures are required, the brine pump may be kept running, circulating the brine which is still cold.

Whether the brine or direct expansion system should be used, depends entirely upon conditions, which should be thoroughly investigated before either system is installed.

The Manufacture of Ice.

There are two methods of ice making, namely, the can system and the plate system, both of which offer special advantages under certain conditions.

The Can System.

In order to produce clear and pure ice by this method, it is necessary to distill the water used for freezing, so as to free it from all organic matter, air, disease germs, etc. The distilling apparatus which serves this purpose is therefore a very important factor in an ice plant. The distilling plant comprises a steam separator, steam condenser, skimmer, reboiler and flat cooler. The steam separator is connected to the exhaust pipe from the steam engine. All impurities, such as grease, etc., carried by the exhaust steam, are removed and then the vapors are passed through a steam condenser, over which the waste water from the gas condenser is allowed to flow. After leaving the steam condenser the condensed water passes through a skimmer where most of the impurities are removed. The condensed, distilled water contains air and sometimes other volatile substances, possessing more or less objectionable odor. To free it from this, the water is subjected to a vig-

orous re-boiling in a separate tank. The distilled and re-boiled water is then passed through a flat cooler, over which the cold water passes, and its temperature reduced.

As a still further means of purification, charcoal filters are used, through which the water passes into a storage tank provided with a direct expansion coil. In this tank the water is cooled as near to its freezing point as possible and is then drawn off and filled into the ice molds or cans, which are immersed in a tank filled with brine. Cooling coils are submerged in this tank, through which the expanding gas travels, absorbing the heat from the brine and reducing it to the required low temperature of 12 to 15 degrees Fahr. The brine in the freezing tank is well agitated, causing an even temperature throughout and slowly freezing the water in the ice cans. After the ice is frozen solid, the can is hoisted out of the tank (by a hoisting apparatus, which is movable) and conveyed to the thawing apparatus, where the ice in the can is loosened from it (either by immersing the can into a bath of warm water, or by an automatic sprinkling and dumping apparatus) and discharged into the storage room.

The Plate System.

The plate ice system has an advantage in that it is not necessary to distill or boil the water if otherwise pure. The ice, which forms slowly on hollow freezing plates immersed vertically into tanks filled with water, purifies itself of any air or other impurities. On the other hand, it is an established fact that the plate system requires more skill to operate successfully and the plant is generally more expensive to install and keep in repair. Local conditions, price of coal, quality of water, etc., determine which system should be given the preference.

The plate system embraces three distinct types. The brine plate system, in which the direct expansion coil is submerged in brine between two plates a few inches apart, the brine acting as a medium of contact between the direct expansion pipes and the plates, the ice freezing on the outside of the plates.

In the dry plate system, the gas coil is clamped between two plates which are rapidly cooled by direct expansion coils, the ice forming on the plates.

The third system is the block system, in which the water freezes directly to the bare direct expansion coils, from which it is harvested by cutting it into blocks with a vertical steam cutter.

The freezing time required for a plate ten to twelve inches thick is from six to eight days. After the ice has formed to the required thickness it is loosened from the plates, hoisted out of its compartment, cut into blocks of proper size and discharged into the storage room.

This system of ice-making is independent of the use of steam, except the small amount required for loosening the ice ends in the compartments and for cutting the ice plates, so that electric or water power can be applied wherever available at a low rate.

The evaporation or expansion of the carbonic anhydride takes place in coils of extra heavy wrought-iron pipe. For brine tanks, water coolers, small refrigerators and rooms the pipes are welded into coils of continuous lengths and in large rooms the pipes are connected by flange unions.

Safety.

In connection with the high pressure side of the cylinder is a safety valve for the purpose of insuring against accidents. This safety valve is placed in the high pressure channel between the gas discharge valves and the discharge stop valve. The purpose of this valve is two-fold. It will relieve the cylinder and also the system of a pressure that has risen above the normal in case of a fire or through lack of condenser water, and it will also guard against carelessness of the operator who might attempt to start the machine without first opening the discharge stop valve. As the action of the safety valve is accompanied by a loud report it will direct the attention of the operator to the machine. When the pressure again becomes normal this valve closes automatically. This safety valve is designed to blow off at a pressure considerably below that at which the machines are tested.

The time of freezing a certain cake of ice depends largely upon the amount of water to be frozen. Cakes 8 to 11 inches thick require from 38 to 54 hours, with brine at 14 to 15 degrees Fahr.

All water for condensing and cooling purposes goes through a series of operations. It is first used on the gas condenser, then on the steam condenser and cooling coils of the distilling outfit and finally, when quite warm, it is used for feeding the steam boiler.

The best arrangement of an ice factory operating on the can system, with distilled water, is to locate the gas condenser high enough to allow the water used on same to flow by gravity to the distilling apparatus and down to the feed water heater.

The inlet and outlet of the cylinder are provided with stop valves by means of which the system can be shut off, allowing access to the cylinder without loss of gas from any part of the system.

Meat, fish and butter, zero to 10 above zero.

Beer, 25 to 35 above zero.

Ice manufacturing, 10 to 20 above zero.

One ton of good coal will make 6 tons of ice.

Ice Machine and Its Power.

One and one-half to two H. P. will take care of a ton machine in the small class, such as butcher shops, creameries and cold storage.

Handy Information for Mechanical Refrigeration.

Joints.

The way in which the piping is attached to the fittings is interesting. The piping of strictly wrought iron comes to us from the mills with plain ends, cut in exact lengths. Upon receiving an order in our shops for a stock of condensers, the pipe is carefully threaded to suit the fittings. A workman then grinds the pipe on an emery wheel about 1 inch back of the thread. While this is being done the fittings are allowed to swim in a solder bath; directly next to this is a bath of tin, in which the threads are thoroughly

tinned. The fitting is taken from the solder bath and placed in a positive position in a form. The pipe is then screwed into the fitting, after which the recesses in the return bend and the threads exposed are thoroughly solder-covered and in cooling, the pipe and fitting shrink into practically a homogeneous mass.

After cooling, this pipe is fitted with a blank flange on one end and to the other end is attached an air connection, admitting from 300 to 400 pounds of air. The pipe is next submerged in a tank of water, when any leak present would be indicated by bubbles on the surface of the water. All pipes which do show leakage, are at once rejected. The result of this painstaking process is that leaks and the Triumph ammonia condenser are not found together.

Cost of ice for cooling 2700 cubic feet, $50 per month.

Cost of mechanical refrigeration in same plant, $5 per month.

The double pipe type of ammonia condenser is in use in far more than 50 per cent of the plants built today—evidence that this style of apparatus is giving abundant satisfaction under almost every condition an ammonia condenser must meet.

The Ice Tank.

Not many years ago, tanks of wood were considered satisfactory for ice making service. This is no longer true, however, since thoroughly seasoned lumber has become more and more scarce and expensive. Then, too, tanks of steel offer advantages lacking in the wooden construction.

The steel sheets may be easily transported and erecting labor is considerably reduced by using the metal tank. When correctly installed, the durability of the metal tank cannot be surpassed.

The steel tank which is used is usually of ¼ inch material, from 3 to 6 feet deep, depending upon the size of cans.

Sulphur Dioxide

Sulphur dioxide boils or vaporizes at 14 degrees Fahr. under atmospheric pressure or zero pounds gauge pressure. At higher pressures the temperature of vaporization is also higher; at lower pressures this temperature is reduced. The normal condensing pressure is about 50 pounds.

Soldered Joints.

Soldered joints may be made in a number of ways, one of which will be described. Muriatic acid is used, a few pieces of zinc having been dropped in the vessel containing it to make the acid work. Powdered sal ammoniac is used to make the solder flow freely and the tools required are: an iron spoon to distribute the solder, and a soldering hook made of iron or copper wire about ¼ inch in diameter, with the end flattened and bent at an angle so that it can be placed in the recess of the flange to be filled with the solder. Before making the joint, all oil should be wiped off the threads and the pipe should be filed clean for an inch or more back of the threads. The flange or fitting is then screwed on tightly and, together with the pipe, is heated with one or more blow lamps. As soon as the parts are heated enough to flow solder, a little acid is poured into the recess back of the flange and acts to remove all grease and dirt. This being done, a small amount of solder is flowed into the recess and rubbed against the surfaces with the soldering hook. In this way the solder is made to take hold of the iron and the use of the hook eliminates the burnt acid and any particles of dirt that may be present. Having tinned the surfaces in this way, the recess back of the flange is filled with solder, a little sal ammoniac being used to keep the solder fluid. While the solder is being poured, the blow lamp must be used to keep it flowing so that all parts of the recess are filled evenly. When this has been accomplished and the solder has hardened, the joint is washed thoroughly to remove any traces of the

acid and a coating of rust-proof paint is applied. From this it will be seen that the process of making the soldered joint is simple, being nothing more than the act of filling in the recess cut out in the back of practically all flanges used in ammonia piping work.

The shrunk joint is the most thorough and at the same time the most expensive of all the methods of making pipe connections. The process of making the joint consists of heating the pipe and fitting in a charcoal fire, rubbing the parts to be joined in sal ammoniac for a few seconds and then plunging them into a pot of melted solder. From the pot, the parts are taken again to the sal ammoniac and thoroughly rubbed, after which they will be found to be perfectly tinned. The pipe is then allowed to cool while the fitting is kept hot and screwed on in the heated condition, it being somewhat expanded owing to the heat. The fitting must be screwed on quickly and tapped with a hammer while being turned so that there is no chance for it to cool or for a film of solder to be formed between the joining surfaces. The idea is to have the solder fill up all imperfections and holes but not to form a film between the joining surfaces as is the case where the lead was disconnected and a spare one put in place.

The Refrigerating Machine.

The refrigerating machine is the heart and soul of the plant and should be of the best design, with proper proportions to give the required capacity when operating under the local conditions of the plant. The compressor with its driving engine or motor is placed in the machine room with the water pumps and other auxiliary apparatus, while the condenser is placed on the roof of the building under a cover or in the third story of a tower as shown in Fig. 16. With this arrangement the water from the ammonia condenser can be passed over the exhaust steam condenser to take up heat from the steam before passing to the feed-water heater and thence to the boilers. As shown in Fig. 16, the ammonia and steam condensers are of the atmospheric type, which is in general use. The cooling water is run over the top pipe of the coil and drips down over the lower pipes until collected in a trough under the coils. About 80 square feet of cooling surface is allowed per ton of ice made in 24 hours.

Where space is limited and the condenser must be placed in the building with other machinery, the spray from water flowing over the coils is objectionable and the double-pipe condenser is used. This is nothing more than a coil of pipe within a coil, so that an annular space is formed between the two pipes forming the double coil. Ammonia enters this space at the top of the coils and flows downward, while the cooling water enters the smaller pipe at the bottom and flows upward. Thus the coolest water is in the part of the coil containing the hottest ammonia and the highest possible efficiency of heat transfer is had. Submerged condensers, consisting of a pipe coil in a tank filled with water, may be used if circumstances require, but this form of condenser is difficult to clean and requires a large amount of cooling water. Also it is difficult to detect leaks, as the leaking ammonia is absorbed by the water. Where the water supply for the condensers is not as cool as could be desired, good results may be had by rigging the double-pipe condenser so that water can be run over the outside of the coils as in the case of the atmospheric condenser.

Compressors are made both single and double acting and have the cylinders either horizontal or vertical. The driving engine should be of the Corliss type with a good releasing valve gear, so that the steam consumption will not be so great that more distilled water is made than is needed for the ice cans. In all except the smallest units and in some designs of extremely large machines, the engines are direct-connected to the same crankshaft as the connecting rods of the compressors. Both simple and compound engines are used and are run condensing or non-condensing as may be required by the local conditions. Where compound engines are used, the cylinders may be connected in tandem or they may be cross-connected, the latter method being preferred for large machines and for machines of the vertical type where two single-acting cylinders are used. The connecting rod of the engine may be connected to the same crank pin as that of the compressor, or it may be on a separate crank of the same shaft.

In small vertical machines having one compressor cylinder, the engine may be set vertical and be connected to the opposite end of the crank shaft from the connecting rod of the compressor, a flywheel being placed on the middle of the shaft. One form of the horizontal machine is that in which the engine is connected to one end of the shaft, the other end of which drives two single-acting horizontal compressors. In still another arrangement, the engine is connected to the middle of a shaft on each end of which is a crank that drives a compressor of either the horizontal or vertical construction. In all of the different arrangements, flywheels are used to give steady working, being placed in various ways according to the disposal of the other parts of the machine. Very large units sometimes have a band wheel on the middle of the crank shaft between the two compressors so that the machine may be driven by belt from a separately mounted engine of proper size.

It is important that the builder of a plant should understand the relative advantages and disadvantages of the different types of construction so that he may make a selection of a machine suited to the conditions under which it is to be operated. It is evident in the first place that the stuffing-box of the single-acting machine can be kept tight easily because it is subjected only to the comparatively low pressure of the suction gas instead of the pressure of the condenser, which ranges from 125 pounds upward. On the other hand, the double-acting compressor is more economical because, at each revolution of the crank shaft, it deals with almost twice as much gas as a single-acting machine of the same cylinder diameter and stroke. With the exception of the extra friction resulting from the necessarily tighter stuffing-box gland of the double-acting machine, the friction of the two machines is the same. Notwithstanding this extra friction, it is estimated that, in comparison with a machine having two gas compressors, the amount of saving with the double-acting compressor is one-eighth of the whole amount of power required to compress the gas.

As the double-acting machine is capable of doing the work of two single-acting compressors, there is considerable saving in the first cost for construction material. This saving is partly offset by the extra

care and expense necessary to properly construct the double-acting machine and by the fact that this machine is rather complicated in the arrangement of valve ports and connecting passages. In any compressor it is important that clearance be made as small as possible consistent with safe working, and this is rather difficult to do successfully with the double-acting machine. In plants using a single machine and the direct expansion system, as where the gas is expanded direct in the coils of freezing plates used with the plate system of ice making, it is important that the compressor be kept in operation. On this account there is an advantage in having two single-acting compressor cylinders instead of one doubling-acting machine, as any accidental damage to one of the compressors can be remedied while the other is kept in operation. By running the single cylinder at increased speed, the plant will make capacity, whereas with the double-acting machine it would be necessary to shut down and allow the temperature of the freezing tank to rise until the machine could be put in operation again.

In considering the relative value of the horizontal and vertical types of machines, it is seen that the vertical machine has the advantage in that the parts wear uniformly. In compressors other than those using the oil injection, the least possible amount of oil is used, and prevention of undue wear on any of the parts is an important consideration. Vertical machines are not subject to bottom wear of the pistons, as are horizontal compressors in which the weight of the piston is supported by the lower part of the cylinder wall. In the horizontal machine, the tendency is to wear the cylinder into an oval shape and to reduce the diameter of the piston until leakage occurs past it. This kind of leakage is difficult to detect and is often neglected. As the cylinder wears, part of the weight of the piston is supported by the stuffing-box gland when the piston nears the crank end of the stroke. This causes unequal wear on the stuffing-box glands so that it is difficult to keep them tight. In the vertical compressor, the suction and discharge valves work up and down so that the wear on their stems is equal in all directions, thus ensuring correct and accurate seating at all times. Other things being equal, the

engineer will give better attention to the horizontal machine because he can see any defect that may show up without having to climb a ladder to hunt for it. It costs more money to build a vertical machine, and for this reason a horizontal machine is in favor where floor space is plentiful. In the end it will be found that the cubic feet of space occupied by machines of the two types is about the same, so that it all depends on which kind of space, vertical or horizontal, is more valuable.

Loss of Liquor.

After a machine has been in operation for some time, the liquor level in the generator may show a tendency to fall until, by restoring it with increased speed of the ammonia pump, the level in the absorber falls out of sight in the gauge glass. This will occur without any apparent cause, the density of the rich liquor meantime remaining standard at 26 degrees. In a new plant, this may be due to insufficient charge, but if after supplying more liquor to restore the proper level in both generator and absorber, the level falls again, something must be done. As a first move the cooling water and the brine in the bath should be tested with litmus to see if there has been any leakage. If the trouble is not found to be leakage, it must certainly be due to some of the liquor being pocketed in a low place in the piping system or in the expansion coils where these are not laid out for the gravity return to the absorber. In such a case, the liquor will be drawn over by making a vacuum on the absorber as in the case of a boil-over. If it is found that there are no leaks and none of the ammonia is pocketed in the coils, the trouble must be due to air in the topmost pipes of the condenser and cooling coils, which has gradually found its way into the absorber and been burnt at the purge cock.

Making Up Ammonia Losses.

Aqua ammonia should at all times be kept up to the standard density of 26 degrees, and if the ammonia pump is in first-class order a somewhat higher density may be used to advantage up to about 28 degrees. The greater the density, the easier the gas is liberated and in case the density has fallen below

standard, to say, 24 degrees, aqua or anhydrous ammonia must be added. The amount of ammonia to be added may be found by consulting the percentage table in Chapter IV, in which it will be seen that aqua ammonia at 26 degrees density contains in round numbers 28 per cent of pure anhydrous ammonia and at 24 degrees density 24 per cent of ammonia, the loss being 4 per cent of pure ammonia. Supposing, for example, that the original charge was 10,000 pounds, 28 per cent of which or 2800 pounds is pure ammonia, we have then to supply 4 per cent of this quantity or 112 pounds of liquid anhydrous ammonia to bring the density of the whole charge up to 26 is restored. Where the freezing tank is elevated to give the gravity return to the absorber, this will be all that is necessary, but otherwise it will be necessary to close the poor liquor valve on the absorber, and start the pump to create a vacuum in the absorber, so that the ammonia will be drawn over from the expansion coils. After the coils are emptied of the liquid, the weak liquor valve to the absorber is opened and the pump kept running in the regular way, or at reduced speed if necessary to keep the liquor in the generator at the proper level. As the temperature of the bath will rise during the righting of the distribution of ammonia in the system, the machine will require special attention until normal conditions have been restored.

Vacuum Test.

To make the vacuum test, the air remaining in the system is pumped out to form a vacuum of 28 or 29 inches, as already mentioned. In doing this, the stop valve on the discharge pipe of the compressor is closed as are also all the valves of the system that communicate with the atmosphere. Communication is made with the atmosphere between the compressor cylinder and the stop valve on the discharge line, this being done by an air valve provided for the purpose or by opening a flange connection as was done on the suction line for the pressure test. All valves connecting the different parts of the system are opened and the machine is started to pump out the air in the pipes. When the desired vacuum is obtained, the machine is left standing for about 6 hours to see if there are leaks of air into the system. If in this time

no leaks are indicated by a fall in the vacuum, the joints may be considered tight and preparations may be made to charge with ammonia.

Before making the pressure test of the system, it is well to test the steam, water, waste, and exhaust steam piping and connections to see that all joints are proof against leakage. Live steam is turned into the steam pipes and a moderate back pressure is had in the exhaust piping by setting the back pressure valve or by throttling the exhaust with stop valves where there is no back pressure valve. Water pipes are subjected to a pressure about 30 per cent in excess of the ordinary working pressure by partially closing the stop valves on the pipes near the condenser and the inlet to the water jacket of the compressor.

When the piping connections of the entire system have been made and the machinery has been set up, adjusted, examined, and found in good condition with the stuffing-box gland properly packed, the plant is ready to be tested for leaks under both internal and external pressure. It is customary to subject the system to internal pressure for the first test and after all leaks that show up in this test have been mended the air may be pumped out until the system shows a vacuum of about 28 or 29 inches. To make the pressure test the stop valve on the suction line is closed and the valves provided between it and the compressor to connect with the atmosphere are opened. Where no such valves are provided, a flange joint between the stop valve and the compressor cylinder may be broken and held open with wedges to admit air to the system. All other valves of the system except those communicating with the atmosphere as at the drains of oil traps, etc., are opened so that the pressure when raised will be equalized over the entire system. Provision is made to lubricate the compressor piston with the smallest possible amount of mineral oil that will prevent the piston rings from seizing and if the interior of the cylinder cannot be lubricated in any other way, the heads must be removed and the oil smeared over the inner walls. The heads are then replaced and the bolts set up evenly and tight.

Making Tight Joints for Ammonia Work.

Select good strong piping of reliable manufacture, the next point is to see that the threads are properly

cut. All threads on the ends of pipe and in fittings should be cut true and sharp and if cut on the lathe, should be chased with care. If a die stock is used, it should be in the best of condition with the dies good and sharp. No amount of doctoring with solder, lead or other joint-making materials will do any good if the threads are not properly cut and the parts accurately fitted together. Solder has its place in joint making where the joint is to be permanent, but in work of this kind all the greater care should be taken to have the threads properly cut. Where the threads are so poorly cut that they do not fit down closely into the grooves, ammonia has no trouble in leaking out and solder can do little or no good, as it is impracticable to sweat it into all the openings in the threaded joint.

A joint having threads of this kind presents a great temptation to a careless workman or an unscrupulous contractor to jam the two parts of the joint together in an effort to make the joint hold. In doing this, the pipe is screwed into the fitting further than it should go, so that the threads are stripped or additional threads are cut on the pipe. In this way the workman may make a joint that will hold until the contractor gets off the job and out of reach, when it becomes the duty of the unfortunate engineer to shut down the plant or impair its operation by cutting part of the piping out of service for mending the bad joint. Generally it will not be a case of mending, as the threads on the pipe and in the fitting will be found damaged beyond repair so that new threads must be cut on the pipe and a new fitting purchased. Probably the best way to avoid such troubles as this is to have the engineer, who is to operate the plant, on the ground during its erection. If he is a competent man and is given authority to have the work properly done, there will be little trouble in store for the future.

After all, the simplest way to make joints in an ammonia piping system is not to make them. That is to say, every joint that can possibly be dispensed with should not be made, and as few fittings as will do the work should be used. One of the readiest methods of eliminating joints is the use of pipe bends instead of elbows and return bends. It costs money to bend pipe, but where every joint eliminated may

mean the saving of several pounds of ammonia, the price of which quickly runs up into dollars, the increased first cost by using the bent pipe system is of no material consequence. Pipe bends require more space than ordinary elbows and return bends, but the piping may usually be arranged so that little if any additional ground space need be bought.

Even if the pipe bends should necessitate larger buildings and more ground space, there are compensating advantages, one of which is reduced friction of the gases and liquid ammonia passing through the pipes, so that a greater back pressure may be carried with a resulting increased efficiency. Then again there is better provision for expansion and contraction where the bends are used, so that strains in the pipe line are largely eliminated and there is less likelihood of leaks being sprung. The number of joints, used in a plant where the bent pipe system is adopted, depends on the lengths in which the pipe can be manufactured and handled and to some extent on the use to which the pipe is put. In the case of a condenser, for example, where the pipe comes in the same length as the coils are to be made, there will be one joint for every length of pipe instead of two as would be the case if return bends were used. These joints are alternated at opposite ends of the condenser on every other pipe of the coil and are placed about 2 feet from the end of the condenser.

Making Brine.

When ready to make the brine, the tank should be filled about two-thirds full of water and the apparatus for mixing the salt with the water should be put in place. This may be nothing more than an ordinary barrel having a false bottom about 4 inches above the real bottom. Water is admitted to the space between the two bottoms and flows through ¼-inch openings with which the false bottom is perforated into the upper part of the barrel, which is filled with salt to within about 6 inches of the top. A pipe connection for carrying off the brine is made to the upper part of the barrel and a box strainer is placed in the space above the salt over the pipe opening. A well is provided in this strainer box for the hydrometer, and the water supply must be so regulated that this instrument registers 90 degrees. The apparatus may be

placed in any convenient position, as on the floor of the tank room and is simple and inexpensive. It may also be used when the brine is to be strengthened at any time during service. Water is supplied to the bottom of the barrel by the brine circulating pump where one is installed, and in lieu of this one of the water supply pumps may be connected for the purpose, the suction of the pump in any case being connected to draw from the brine tank. Where there is no brine pump, however, and the water pump has to be used, it may be more convenient to start with the tank empty and not partially filled as above instructed. In this case there is no necessity for making a suction connection from the tank to the pump.

Even under the most favorable conditions, some air will be present in the system after the vacuum test and for this reason it is advisable to charge the ammonia by degrees, about 70 per cent of the whole charge being pumped in at the first trial. After the plant has run some time and the ammonia has been well circulated through the system, the air will collect in the highest parts of the piping and may be exhausted at the purge valve on the condenser. The rest of the ammonia will be charged in one or two installments as may seem best under the circumstances. To disconnect the drum, close the valve on it first and then close the charging valve.

About one-third pound of ammonia should be used for each running foot of 2-inch pipe or its equivalent in the expansion coils, so that about 275 pounds would be required for a 25-ton plant. It is better to put in too small rather than too large a charge, as more ammonia can be added with little trouble at any time it may be needed. Too small a charge is indicated by the tendency of the delivery pipe of the compressor to heat and this should be watched carefully, the regulating valve being manipulated so that the normal temperature of the pipe is the same as that of the cooling water leaving the condenser.

Bending Pipe.

In adopting the bent pipe system, care should be taken not to bend the pipes on so small a radius as to injure them nor yet to make the radius so large that the bend looks ungainly and out of proportion. Although some latitude may be allowed in making

bends for certain locations, there should be uniformity throughout the system and the work of bending should be accurate, the turns being made exactly 90 and 180 degrees as the case may be. The bending radius, other things being equal, depends on the size of the pipe and when once a ratio of size of pipe to radius of bend has been decided on, it should be adhered to as far as practicable. Otherwise the plant will present the spectacle of a small pipe, bent on a large radius, along side of a larger pipe bent on a smaller radius. Nothing could be more unsightly. All pipes must be heated before bending and if there is any doubt about the pipe being able to stand the strain of bending, it should be filled with dry sand and capped on the ends before heating. This will insure a smooth bend without kinks. As a precaution against opening the weld, the line of the weld should be put on the side of the bend.

Why Is Raw Water Ice Clear?

Produces pure clear ice by keeping the water in movement or in agitation while it is being frozen. Process does this by feeding a small jet of air through the freezing water from below, and in this way keeping it stirred or in a state of gentle ebullition. When so agitated while freezing, the ice naturally and of necessity freezes crystal clear.

Freezing clear ice from raw water by keeping it agitated with air is not new, but is many years old. Apparatus is so constructed that this essential air feed is outside of the cans and not exposed to the action of cold brine, and hence can never be interrupted by freezing up, which would result in white or opaque ice, until the trouble was located and corrected. Very little power is needed for this air feed, about a cubic foot of air per minute per ton capacity under a pressure of from 3 pounds to 3½ pounds is all that is needed.

Temperature of Brine and Time to Freeze.

To produce cakes of standard weight, from 50 pounds to 400 pounds, as desired, but the 200, 300 and 400-pound cakes are preferably only 10 inches in thickness, and the preferred temperature of the brine is zero or thereabouts. The fact that there is a positive forced circulation of this cold brine in the jackets

of the can results in greatly shortening the time of freezing, and a 10-inch cake of either of the above standard weights, is frozen nearly solid in about 18 hours, and the freezing progresses to a solid cake and the ice is tempered and harvested in 4 more hours, thus completing the freezing, tempering and harvesting of the larger cakes in 22 hours, which allows a margin for the completion of the freeze and the starting of another within the 24-hour period.

The plants are built in separate units or batteries, each producing a certain fraction of the daily product required, the proportion represented by each unit to the daily quantity to be produced, depending on the size of the plant. A 5-ton plant would thus be built in two or three units. A 30-ton plant in six units, or separate batteries, and in still larger plants the units or batteries may run up as high as 20 or 25 tons in each battery. One of these units is usually being tempered and harvested, while the others are freezing.

Hotels and Restaurants.

Refrigerating plants are now being used in leading hotels and restaurants with the best of success. They are particularly well adapted to the requirements where there are a variety of refrigerators to be kept cool. One plant will cool the large meat storage, the vegetable and general storage, the short order box, bakery or pastry box, fish and oyster box, ice cream box, beer storage and back bar, if necessary. It will also make the requisite ice for table use and will cool the drinking water — in fact, do any cooling that is required.

The sanitary feature of a hotel plant cannot be over-estimated, to say nothing about the saving of waste because of improper cooling, and the satisfaction of being able to keep goods day after day in the best of condition without the use of ice with its expense and attendant discomforts.

Creamery Plants.

Refrigerating plants in creameries are usually installed with a brine system. The brine tank is located in the upper part of the cold storage room, keeping the air cold and at the same time furnishing brine to be run through ripeners and milk and cream

coolers. The brine is supplied to the apparatus requiring it by use of a brine pump. It is not necessary to run the ammonia compressor all day, but only long enough to reduce the brine to the required temperature; then when the milk is ready to be cooled, the pump is started and circulates the cold brine to do the necessary work.

The creamery man knows the importance of being able to control the temperature of cream during the ripening process regardless of weather conditions. To be able to turn out a fine uniform grade of butter, a refrigerating plant is a valuable asset—in fact, it is necessary to properly control temperatures. One of our plants will soon pay for itself in labor, cost and increased value of product. To creameries using power for other purposes, the cost of operating a refrigerating plant is very light, as about the only expense is the power and a few cents for oil.

The storage of perishable food stuffs, such as fruits, vegetables, butter, cheese, eggs and poultry, has revolutionized commerce in edibles. It has meant preservation for long periods, transportation for long distances, and re-storage until required, thus making it possible for dealers to buy in quantities when prices are low, without fear of deterioration before sale.

Cold storage, in connection with refrigerating or ice-making plants, has become common and a very profitable business. Many wholesalers of beer and soft drinks, that will preserve their value only in cold temperatures, are using artificial refrigeration for this purpose.

Artificial Refrigeration.

During the past ten years the science of artificial refrigeration has had a very remarkable growth, due to the fact that the experimental element has been to a large extent eliminated.

The refrigerating machine manufacturers have in their own factories made extensive tests on the various types of machines, now offered to the trade; with the result that the prospective purchaser of this class of machinery will receive the apparatus best suited to his particular needs.

At the present time the larger consumers of ice, such as ice cream manufacturers, retail butchers, etc., are exceedingly active in the installation of small machines to furnish the required refrigeration. The many advantages of mechanical refrigeration over the old method of ice, or ice and salt, is in a large measure responsible for this condition.

With a small outfit the butcher is able to maintain lower temperatures in his refrigerator, as well as to keep both the meat and box in a better condition. As an advertising medium, the refrigerated showcase is without an equal, permitting the shopkeeper to display his commodity without becoming contaminated by the handling of his many customers and without deterioration while being displayed in this manner, which is the case in the ordinary display methods, and the loss subsequent thereto.

It is not necessary to operate the refrigerating plant continuously; by installing brine congealing tanks, a sufficient quantity of refrigeration can be stored in these tanks while the plant is in operation, so that during the periods that the machine is shut down, proper temperatures may be maintained in the compartments refrigerated.

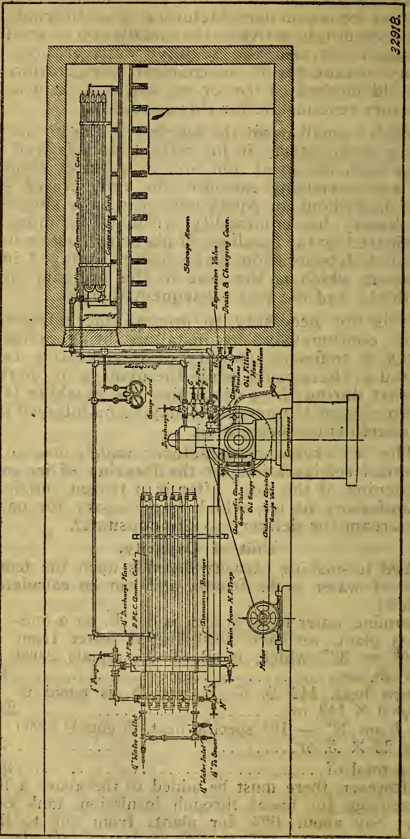
The ice cream manufacturer makes use of mechanical refrigeration for the freezing of ice cream, hardening of the same after it is frozen and for the manufacture of ice, which is necessary for packing the cream for delivery to the consumer.

Unit of Capacity.

Real ice-making capacity depends upon the temperature of water to be frozen, and can be calculated as follows:

Assuming water to be frozen is 80° F. on a one-ton plant, we have 2,000 lbs. of water from 80° = 32° which, in B. T. U. equals 2,000 × 48, or	96,000
Latent heat, 142 B. T. U. per lb. is equal to 2,000 × 142, or	284,000
Ice from 32° — 10° specific heat, .5 equals 2,000 × 22 × .5, or	22,000
Or a total of	402,000

However, there must be added to the above a liberal percentage for losses through insulation, tank covers, etc. Say about 40% for plants from one to fifteen tons capacity and 18% to 25% on larger factories.


32918.
Ammonia Expansion Coil
Suction
Expansion
Storage Room
Expansion Valve
Drain & Charging Conn.
Suction
Discharge
Gauge Board
By-Pass
Ammo. Strainer
Oil Filling Hose Connection
Compressor
Discharge
Automatic Closing Gauge Valve
Oil Gauge
Automatic Closing Gauge Valve
4" Discharge Main
Ammonia Receiver
1" Drain from H.P. Trap
Motor
H.P. Trap
1" Purge
4" Water Outlet
4" Water Inlet
4" To Sewer

At the present time the enclosed type single-acting vertical oil enclosed refrigerating machine is the best suited for this class of work that has yet been manufactured. They are made both steam and belt driven, as well as single and double cylinder, according to capacities required, and are built in sizes ranging from one-half ton to twenty tons refrigerating capacity. The belt driven machines can be operated by any power available, such as electricity, gasoline or gas engine, or water power.

The manufacturers of these small machines have endeavored to build an outfit that will meet a wide range of conditions, with the result that these machines are partically "fool-proof." It is not necessary to employ experienced help to operate these small plants, and with a reasonable amount of care and judgment in operation, the results obtained are so much better than those secured by the old methods, that it is a question of only a short time until mechanical refrigeration will be used by every up-to-date retail butcher and ice cream manufacturer.

The uncertainty of the natural ice crop, which is so often of a poor quality, and the inadequate supply of artificial ice in many localities, together with the high prices which prevail under these conditions, makes, to the large consumer of ice, a necessity of what but a few years ago was considered a luxury—a small mechanical refrigerating plant to replace the use of ice.

Standard Ice Making Units

Capacity Lbs.	Cans	Weight Lbs.	Rows	Outside Dimensions
180	3	60	1	7′ 4″ x 2′ 6″ x 4′ 1″
360	6	60	2	7′ 4″ x 3′ 2″ x 4′ 1″
360	6	60	3	5′ 10″ x 3′ 10″ x 4′ 1″
540	9	60	3	7′ 4″ x 3′ 10″ x 4′ 1″
720	12	60	3	8′ 10″ x 3′ 10″ x 4′ 1″

Size of cans 5″ x 14″ x 32″

Mechanical refrigeration to the market is no longer an experiment—it is a necessity, and once a plant is installed, the owner will never go back to the old, unsatisfactory, wasteful and unsanitary method. He knows that he has refrigeration when he needs it; his stock is in much better condition and can be held for a much longer time; choice cuts can be aged without deterioration; veal and pork do not get wet and slimy.

Temperature Required to Preserve in Cold Storage Various Articles of Food.

The table of approximate temperatures given below will give you an idea of the purposes for which ice making and refrigerating machinery can be employed with profit to its users.

Articles	Deg. Fahr.
Apples	30-36
Asparagus	33
Bananas	55
Beans, fresh	32
Beans, dried	45
Beef, fresh, short carry	35
Beef, fresh, long carry	30-32
Beer, in barrels	33
Beer, in bottles	45
Berries	36
Butter	14
Butterine	20
Cabbage	33
Cantaloupes, short carry	40
Cantaloupes, long carry	33
Carrots	33
Cheese	33-38
Chocolate, dipping room	65
Cider	32
Celery	32
Cigars	42
Corn, dried	34
Cranberries	33
Cream	33
Cucumbers	38
Currants	32
Dates	55
Eggs	32
Figs	55
Fish, fresh water, frozen	18
Fish, salt water, not frozen	16
Fish, to freeze	5
Flowers, cut	36
Fruits, canned	40
Fruits, dried	40
Game, short carry	28
Game, after frozen	10
Game to freeze	0
Ginger Ale	36
Grapes	36
Honey	45
Hops	32
Huckleberries, frozen	20
Ice	28
Ice Cream, short carry	15
Lemons, short carry	50
Lemons, long carry	36
Lambs	32-40
Lard	40
Livers	20
Maple syrup and sugar	45
Meats, salt, after curing	35
Mutton	32-40
Nursery stock	30
Oleomargarine	40
Onions	32-35
Oils, cotton seed	35-40
Oranges, short carry	50
Oranges, long carry	34
Oxtails	30
Oysters, in tubs	25
Parsnips	32
Peaches	36
Pears	33
Peas, dried	40
Plums	33
Pork	30
Potatoes	34
Poultry, short carry	28
Poultry, after frozen	10
Raisins	55
Ribs, not brined	20
Salt meat, curing room	32
Sardines, canned	35
Sausage casings	20
Scallops, after frozen	16
Shoulders, not brined	20
Sugar	45
Syrup	45
Tenderloins	33
Tomatoes, ripe	42
Watermelons	32
Wheat flour	40
Wines	45
Woolens	28

Cold Storage Boxes and How to Build Them.

Artificial refrigeration has in the last ten years or so, to a great extent, taken the place of cooling with ice. It is much cleaner and convenient and also cheaper.

With a machine it is possible to keep the temperature at all times to within a few degrees of the temperature wanted. Nowadays we find in all up-to-date butcher and grocery stores, etc., also in hotels, big and small and even in modern apartment houses, the cooling of boxes done by means of a refrigerating machine. These machines are of two kinds, one using ammonia, the other carbonic acid gas (called $CO2$).

The best refrigerating rooms and boxes are made of pure cork boards. The most approved way of building these rooms or boxes is shown in the accompanying plan view of a refrigerating box. The walls are always erected of two thicknesses of 2" cork boards with a ½ inch to ⅝ inch thick Portland cement mortar coat between.

Care should be taken to break joints both horizontally and vertically. The exposed cork surfaces should be covered with expanded metal and receive two coats of Portland cement plaster. The first coat being a scratch coat, the second a float or smooth finishing coat. Ceiling and floor should also have four inches of cork insulation. For boxes located in a basement, when floor in the box is to be level with floor outside of the box, excavate to a depth of ten inches below the floor grade and lay a four inches thick concrete bed of the same size as the outside dimensions of the box. Then lay two thicknesses of two inch thick cork boards with a half inch cement coat between, breaking joints both ways. On top of the cork boards lay a 2½ inch thick cement floor, ¾ inch of this being a finishing coat.

The floor of the box should be ¾ inch to one inch higher than the floor of the basement to prevent water running in. Cement floor should not be laid until the walls are erected. If box is built on a wood floor then lay two thicknesses of heavy water proof building paper. The first dry, the second in hot asphalt cement on the wood floor, then two layers of

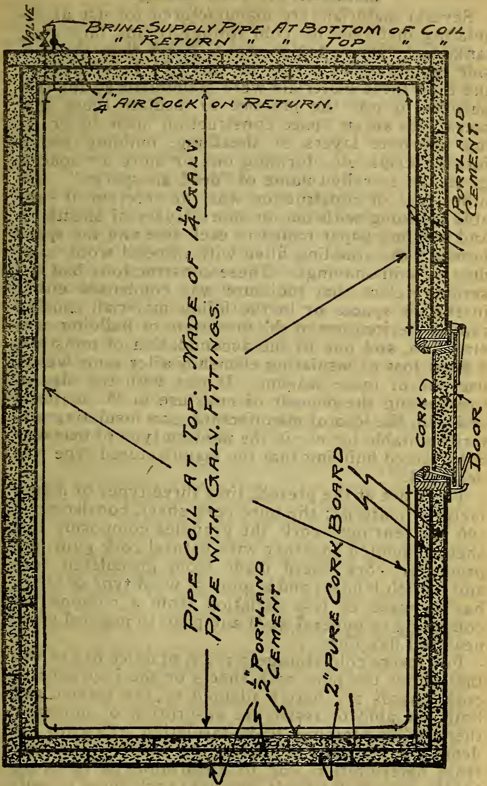
two inch thick cork boards as described before, or they can also be laid in hot asphalt cement. After the walls are erected, put in the $2\frac{1}{2}$ inch thick cement floor. Ceiling of a box is made as follows:

After the walls are up to the required height, nail a 2″ x 6″ wall plate to the top of the four cork walls, then place 2″ x 8″ joists on 18″ centers. To the lower edge of the joists nail a ⅞″ thick D. & M. flooring. Apply either hot asphalt cement or Portland cement mortar to the cork boards and nail them securely to the flooring. The second layer of cork boards should also be set in either hot asphalt cement or Portland cement mortar and also be nailed to the first layer of cork boards, as the nailing will hold the boards in place until the cement is set. Ceiling should also have a two coat cement plastering.

A very convenient way to apply the Portland cement plaster to the cork boards is to build a wood frame 18″ x 36″ inside dimension and 2⅝″ high (the size of standard cork boards), hinged together at one corner. Lay the frame on a table and insert the cork board, then fill in to the edge of the frame with the Portland cement mortar and scrape off. Open the frame, remove the board and place it on the walls or ceiling, as may be the case. When applying the boards to the walls or ceiling, rub them slightly back and forth and up and down, as they then will adhere better to the wall. It is well to use a straight edge to see that there are no low or high places. Should there be a high corner or side, it can easily be forced in with a hammer or mallet.

Cement mortar should be of the following proportions: One part of Portland cement to two parts of sharp clean sand. Doors and windows should be of what is called the "cold storage" kind and should never be of the home-made variety, as it is very important that they are air proof.

Doors are from 5″ to 6″ thick cork lined. Windows have triple glass, forming two air spaces. There are many manufacturers of this kind of doors and windows.


VALVE
BRINE SUPPLY PIPE AT BOTTOM OF COIL
" RETURN " " TOP " "
1/4" AIR COCK ON RETURN.
PORTLAND CEMENT.
PIPE COIL AT TOP. MADE OF 1 1/4" GALV. PIPE WITH GALV. FITTINGS.
CORK
DOOR
2" PURE CORK BOARD
1/2" PORTLAND CEMENT

Insulation for Cold Storage

Several materials are manufactured for use as insulating materials for cold storage rooms, buildings, tanks, etc., where temperatures lower than the outside temperatures are to be carried. Previously to the time these materials were manufactured for this purpose, it was the practice to insulate these surfaces with an air space construction made by erecting alternate layers of sheathing, building paper, furring strips, etc., forming one or more air spaces, given the so-called name of "dead air-spaces." Another type of construction was the erection of suitable studding with one or more layers of sheathing and building paper nailed to each side and the space between the studding filled with mineral wool, sawdust or mill shavings. These constructions had the serious defect that moisture was condensed either in the air spaces or in the filling material, causing rapid deterioration of the insulation or building construction, and due to the accumulation of moisture, a great loss of insulating efficiency after same was in use one or more seasons. It was with the idea of overcoming the deposit of moisture in the material and with the idea of manufacturing an insulating material suitable for use in the modern type of masonry constructed building that the manufactured type was designed.

There are at the present time three types of manufactured material: the pure cork sheet, consisting of 100 per cent pure cork, the granules composing this sheet cemented together with natural cork gum; impregnated cork board made from granulated cork and a pitch binder; and a mineral wool type of sheet, having more or less variation from a composition consisting of mineral wool and peat, to mineral wool, peat and flax fibre.

For severe cold storage service, practice has shown that either the pure cork sheets or the impregnated cork boards are better adapted to the service and both are able to resist the absorption of moisture, thereby maintaining their insulating efficiency indefinitely, and also protecting the building structure from deterioration due to absorption of moisture. Of the two cork boards, the pure cork sheet is more efficient and better suited to general insulating conditions.

Where insulating sheets are to be erected against wooden surfaces one or more layers of insulating paper should first be erected, and a course of the cork sheets well nailed to the surface. If two courses are desired, it is recommended that the second course be erected against the first in a Portland cement bed, the same as tile or other similar material is erected, after which the surface can be given a surface coat of Portland cement approximately ½" thick. If the surface against which the insulation is to be erected is of masonry construction, either brick, concrete, tile or stone, the first course can be erected in a bed of Portland cement the same as described above, the second course erected in a similar manner and finished with Portland cement. The sheets may also be erected in a bed of hot asphalt, but this type of construction is not recommended generally, except for floors, for the reason that the average asphalt on the open market is liable to deterioration in time, due to evaporation of volatile oils, and also for the reason that the bond between the cork sheets and the asphalt is not as strong as between the cork sheets and Portland cement. In laying insulation on floors asphalt may be used to good advantage and is therefore recommended.

Any kind of a working floor suitable to the industry may be laid directly on top of the cork board. A concrete floor consisting of 2" of stone or cinder concrete and a 1" Portland cement top is most generally used. For work in breweries or other industries where considerable water is experienced, an inch and a half asphalt mastic floor is often used. Where a wooden floor is desired, suitable nailing strips may be let in the top course, to which any thickness of wooden floor desired may be nailed. If a sheathed surface is desired against the wall or ceiling insulation instead of Portland cement as described above, such a surface may be had by letting in the top course of cork sheets suitable nailing strips, to which the sheathing may be erected. It is to be noted, however, that this type of finish is now almost absolutely discarded in favor of the Portland cement, since it is likely to deteriorate under cold storage conditions, due to the moisture usually met with in this service.

Where the building is so designed that air-spaces will be formed, it is recommended that these spaces be filled with granulated cork so as to prevent the absorption of moisture, same as described above for dead-air space construction, which was formerly used.

For the insulation of brine and ice making tanks the floor on the tanks can be insulated with one or more courses of cork sheets, each course laid in hot asphalt and the top heavily coated with hot asphalt, after which the tank may be placed directly on top of the insulation. For insulating around the sides of these tanks two methods are suggested. One—the building of a suitable retaining wall either of brick or wooden sheathing, located the proper distance from the tank and the space between the retaining wall and the tank filled solidly with granulated cork. The other construction is the erection of suitable studding directly against the tank sides and nailing of sheet cork to the outer edge, and filling between the studding solidly with granulated cork and finishing the exposed cork sheets with Portland cement same as described above for cold storage rooms.

Experience has shown that the following thicknesses of sheet insulation are good practice:

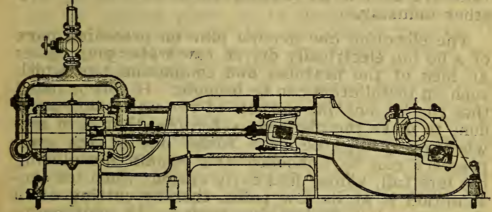
For temperatures from 50 degrees upwards 2″
For temperatures from 32 to 50 degrees ...3″
For temperatures from 20 to 35 degrees ...4″
For temperatures from 10 to 25 degrees ...5″
For temperatures from 0 to 15 degrees ...6″
For temperatures from 0 and below ......6″ to 8″

The above thicknesses are good for rooms to which maximum refrigeration is applied 24 hours per day. If it is desired to maintain practically constant temperatures with the machine shut down, say 12 hours per day, one to two more inches of insulation should be erected than above given.

The care with which insulation is erected has a great bearing on the length of life and its value to the owner. Insulation erected by those not thoroughly experienced is liable to fall, is liable to collect moisture and be unsatisfactory regarding efficiency, appearance and length of life. All joints should be butted tight and properly broken so as to prevent passage of moisture or air through the insulation and all the work erected solidly and with the proper care.

The Raw Water System of Ice Making.

During the past very few years, the system of manufacturing ice direct from raw water, *i. e.*, undistilled water, has come into extraordinary favor, so much so that by far the greatest amount of installations in tonnage in new ice making plants has been (particularly in large centers) raw water and not distilled water plants. The reason for this is quite obvious, as, in the first place, raw water ice is—in many respects—superior to distilled water ice on account of its freedom from lubricating oils, boiler compounds and the consequent undesirable odors; secondly, because in ice made from raw water, all essential salts and beneficial chemicals are retained and not boiled off, as in the case in making



distilled water ice. Thus, raw water ice results in a more palatable product by far—the difference in taste being detectable at once.

Electrically driven raw water ice plants are of extraordinary simple construction and possess these advantages: the up-keep and cost of repairs and supplies are nominal as compared with other types, the depreciation is less than half that of distilled water plants. The labor for operating a raw water plant is not required to possess any particular skill or knowledge and on account of the absence of the steam boiler, the fireman is eliminated. No coal or ashes need be bothered with and this also results in a greater degree of cleanliness and sanitation about the ice plant. Further, an electrically driven raw water plant can be located anywhere desired and not

necessarily adjoining a railroad, unless, of course, the bulk of the ice is shipped; otherwise, particularly in large cities, such plants—to avoid long hauls in delivering—can be located directly within a residence district, as there is no nuisance, such as smoke or noise, connected with them.

Electric power companies have recently become enthusiastic over the possibilities presented by raw water ice plants as power users—because of the fact that such plants have a maximum demand for power when other demands, such as for light and street railway service, are at their lightest and vice versa. As a result electric power companies are encouraging the building of such plants, as they tend to balance up the electric power plant load and, in consequence, more attractive rates for electric current are quoted ice making plants than most any other industry.

The *elevation and ground* plan on preceding page of a 60 ton electrically driven raw water plant gives an idea of the neatness and compactness to which such an installation can be brought. It will be noted that the *ice machine* consists of two units, this being done to make the plant more flexible; that is to say, when operating the year round one of the *compressors* can be unhooked and remain idle during the late fall, winter and early spring, when ice consumption is at its low point, thereby cutting down the power bill during this period. In addition to the compressors, air blowers are supplied for agitating the water within the cans, also a core pump for removing the core water, which contains what minor impurities—not extracted by the filters—might remain in the water with which the cans are filled, these minor impurities having been cast off during the process of freezing into the unfrozen core, which is extracted through a special sucker tube connected by hose with the core pump. The core pockets are next filled with filtered water, so that each cake is frozen solid throughout and becomes exceptionally clear and crystal-like when finished. The usual propeller is found as in other plants for agitating the brine in the freezing tank. In the plant shown in the diagram a special type of electric crane is used, which has a capacity of lifting three 400 pound cakes at once, transporting them to the dip and dumping

table on harvesting. The plant shown has—in addition—an electrically driven centrifugal water pump which pumps the water used on the condenser back over the cooling tower, the purpose of this being to economize on condenser water, which is used over and over again.

As water is supplied from city mains, which is charged for at meter rates, by means of the cooling tower, the consumption of water is limited to that which is actually converted into ice in the freezing process and the small amount required to replace that carried off by evaporation at condenser and cooling tower.

With a well-balanced plant—such as the one shown—the electric power consumed is very low compared with the ice output, a matter of from 35 to 45 K. W. hours per ton of ice produced. A very great advantage in electrically driven plants—which is also the case with any other type of refrigerating or ice making plant—is to provide abundant ammonia condensers for the purpose of keeping the high pressure down as low as possible and a very large can surface to permit of higher brine temperatures which—resulting in a slower freezing process—produces a better cake of ice and one not liable to crack in harvesting, and, what is of greatest importance, the bringing nearer together of the high and low ammonia pressures, results in a much lower power consumption per ton on account of the greater volume of ammonia gas being pumped while these pressures do not range so far apart.

The ice machines used in this installation are of an extraordinary type known as the SAFETY ammonia compressor, which has been patented and is manufactured by a number of reliable concerns throughout the country. A feature of the SAFETY compressor is the peculiar location of the suction and discharge valves, as will be noted on the skeleton drawing shown. The possibility of wreck and consequent loss or damage resulting from breakage of valve or the dropping of valve part into cylinder and also from liquid shock is by this construction entirely eliminated.

Electrical Units.

The electric units are as follows:

Volt—The unit of electrical motive force.

Force required to send one ampere of current through one ohm of resistance.

Ohm—Unit of resistance. The resistance offered to the passage of one ampere, when impelled by one volt.

Ampere—Unit of current. The current which one volt can send through a resistance of one ohm.

Coulomb—Unit of quantity. Quantity of current which, impelled by one volt, would pass through one ohm in one second.

Farad—Unit of capacity. A conductor or condenser which will hold one coulomb under the pressure of one volt.

Joule—Unit of work. The work done by one watt in one second.

Watt—The unit of electrical energy, and is the product of the ampere and volt. That is, one ampere of current flowing under a pressure of one volt gives one watt of energy.

One electrical horse-power is equal to 746 watts.

One kilowatt is equal to 1,000 watts.

To find the watts consumed in a given electrical circuit, such as a lamp, multiply the volts by the amperes.

To find the volts, divide the watts by the amperes.

To find the amperes, divide the watts by the volts.

To find the electrical horse-power required by a lamp, divide the watts of the lamp by 746.

To find the number of lamps that can be supplied by one electrical horse-power of energy, divide 746 by the watts of the lamp.

To find the electrical horse-power necessary, multiply the watts per lamp by the number of lamps and divide by 746.

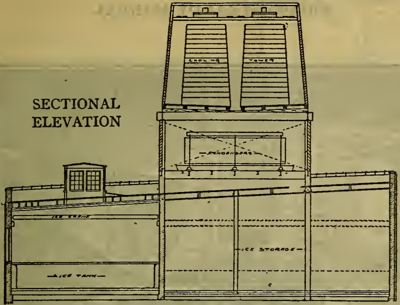
To find the mechanical horse-power necessary to generate the required electrical horse-power, divide the latter by the efficiency of the generator.

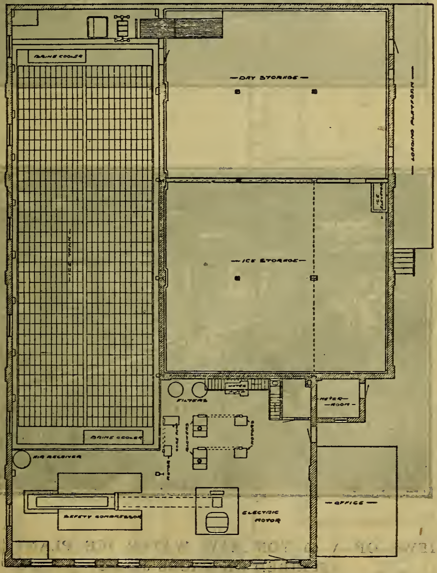
To find the amperes of a given circuit, of which the volts and ohms resistance are known, divide the volts by the ohms.

To find the volts when the amperes and watts are known, multiply the amperes by the ohms.

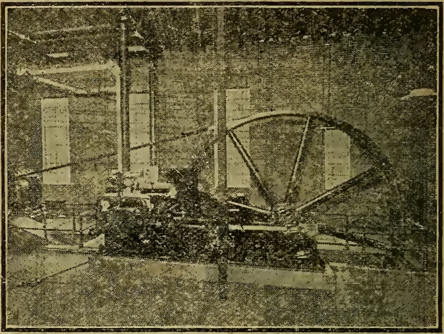
To find the resistance in ohms, when the volts and amperes are known, divide the volts by the amperes.

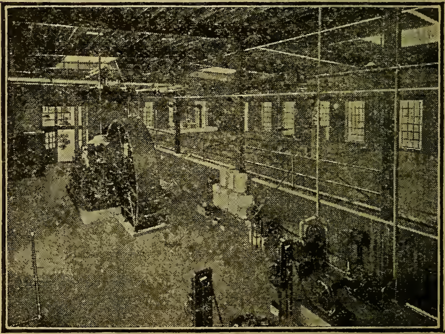
SECTIONAL ELEVATION



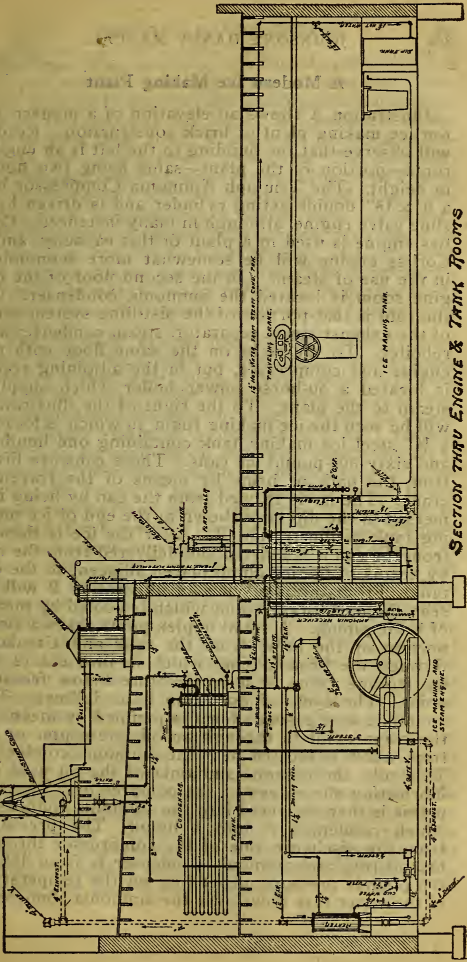


FLOOR PLAN





VIEWS OF A 60 TON RAW WATER ICE PLANT DESCRIBED ON PAGES 360-362



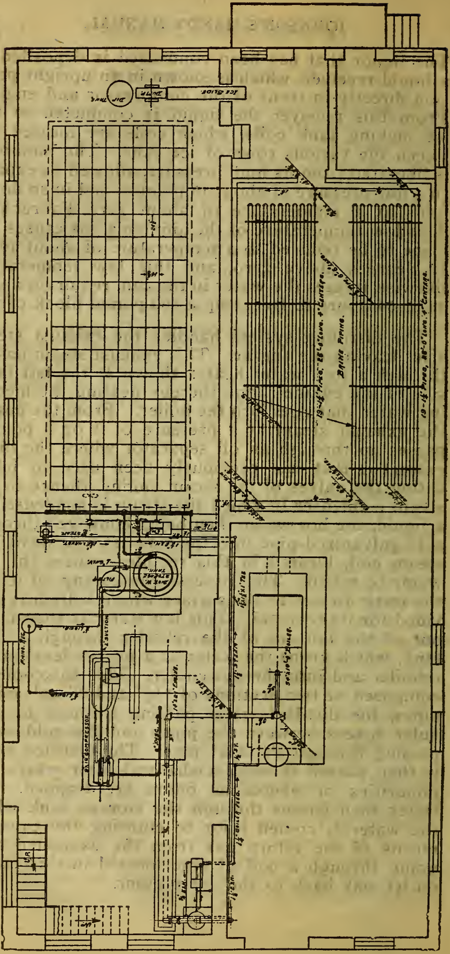
SECTION THRU ENGINE & TANK ROOMS

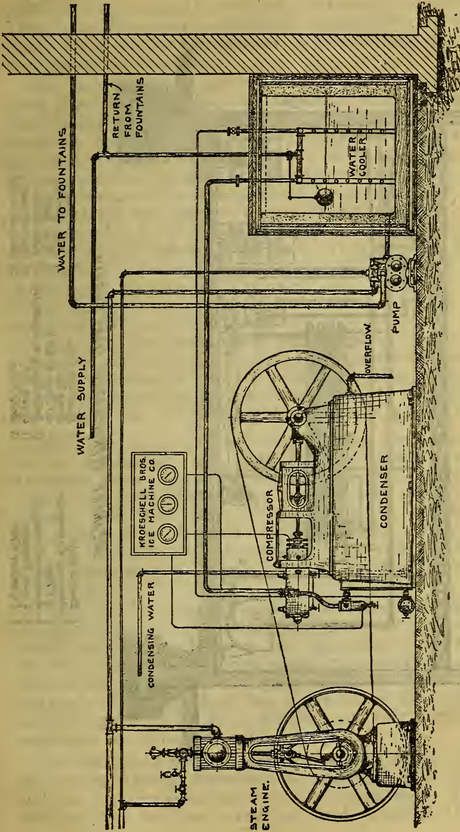
A Modern Ice Making Plant

Illustration A shows an elevation of a modern 10-ton ice making plant of brick construction. Reader will observe that the building to the left is an engine room—portion of the plant—same being two floors in height. The Triumph Ammonia Compressor has a 9″ x 18″ double acting cylinder and is driven by a slide valve engine, although in many instances a Corliss engine is used in a plant of this capacity, and a Corliss engine will be somewhat more economical in the use of steam. On the second floor of the engine room is located the ammonia condenser. On the roof is that portion of the distilling system aside of the exhaust steam separator, steam condenser and reboiler. To the right on the same floor with the engine and compressor, but in the adjoining room, is located a 50-horse power boiler which supplies steam to the plant. To the right of the illustration will be seen the ice making room, in which is located a ¼″ steel ice making tank containing one hundred and sixty 300-pound ice cans. These cans are lifted from the bath or brine by means of the traveling crane. The ice is thawed from the can by being immersed in the dip tank shown at the end of ice making tank in illustration B. After the ice is thawed from the can it is hoisted and delivered from the can by means of the ice dump placed adjacent to the dip tank. From the plan view in illustration B will be seen the ice storage room which is cooled by means of brine piping. A small duplex pump takes a small portion of the brine from the tank and circulates through the brine piping, which in turn enters the ice storage room at a temperature below freezing point. The cycle of operation is as follows: The ammonia in a gaseous form is pumped by means of the compressor in through an oil intercepter or oil trap, which is located near the ammonia condenser. This robs the gaseous ammonia of the oil used for lubricating the valves of the compressor. The ammonia is then delivered into the ammonia condenser, which condenses it into a liquid. The pressures from the discharge side of the compressor through the oil trap and ammonia condenser is from 150 to 200 pounds pressure, depending on the temperature of the water that flows over the ammonia condenser.

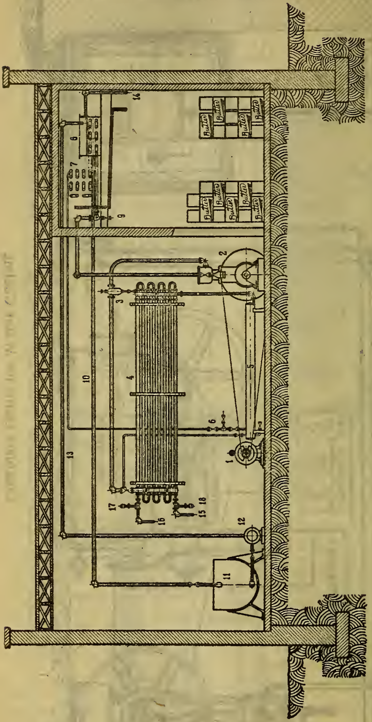
The liquor that has been condensed is deposited in a liquid receiver, which is shown in an upright position directly in front of the compressor and engine. From this receiver the liquid is conducted to the ice making tank coils, which coils are located between the various rows of ice cans. The ammonia is liberated from its high pressure, allowed to expand to a low pressure of about 15 pounds, and in so doing boils at a temperature of about zero Fahrenheit. This low temperature of the ammonia gas causes the brine to be reduced to a temperature of about 10 or 12 degrees above zero, and this low temperature likewise freezes the water in the can, requiring about 48 to 54 hours to freeze up a 300-pound block of ice.

The distilling system handles the exhaust steam after leaving the engine. This exhaust steam passes through a feed water heater shown at the left hand side of the engine room, thereby heating the incoming water that goes into the boiler. From the heater the exhaust steam at a pressure of 2 or 3 pounds passes up through an oil separator where the oil is extracted that has previously been used in lubricating the valves of the steam engine, thence to the steam condenser in which the steam is condensed to a liquid, the hot water then being conveyed through a 1" galvanized pipe into the reboiler. A small live steam coil, located in this reboiler, causes the hot water to reboil. This process causes any oil left in the water to rise to the surface where a drain is provided for its removal. This hot water is then taken out of the bottom of the reboiler through a float tank, which keeps the water at a proper level in the reboiler and into the flat cooler. This flat cooler is composed of two sections of 1¼" and 2" galvanized pipes, the distilled water passing through the annular spaces between the pipes and the cold water passing through the 1¼" pipe. The distilled water is then passed through a charcoal filter where any impurities or obnoxious odors are trapped. The water then passes through the storage tank where the water is cooled prior to entering the cans, by means of the return gas from the expanded coils going through a coil of pipe located in this cooler on its way back to the compressor.


BRINE PIPING.
SUCTION



Complete Outfit for Water Cooling



CREAMERY REFRIGERATING PLANT DIAGRAM

1 Electric Motor
2 Ammonia Compressor
3 Oil Trap
4 Ammonia Condenser
5 Liquid Receiver
6 Expansion Cock
7 Expansion Coils
8 Brine Tank
9 Oil Drain for Coils
10 Brine Supply to Cream Vat
11 Cream Vat
12 Brine Pump
13 Brine Return
14 Brine Overflow
15 Water Inlet
16 Water Outlet
17 Washout Inlet
18 Washout Outlet

The past few years have shown a wonderful awakening of interest in the subject of artificially cooling Dairy and Creamery Products on account of the many disadvantages possessed by the old manner of cooling by natural ice.

The progressive creamery and dairyman has not been slow to realize the vast superiority of the modern method of cooling because of the many sanitary features, simplicity, cleanliness and efficiency,—the artificial cooling doing away with the contaminating influences of natural ice which often being cut from filthy ponds, rivers and lakes, is a ready vehicle of disease from the time it leaves its place in the ice house until it is eventually dragged into the refrigerator, leaving behind it a long train of dirt and moisture. The only barrier that formerly stood in the way of cooling by machinery was the price, or initial cost, which, owing to the crude method of manufacture was rather high; it has, however, by the use of modern machinery and tools been reduced to a very reasonable basis, and the expense of maintenance and cost of operation has also been brought down to where this item becomes quite a saving in the cooling bill, when once the machinery is installed.

The Vilter Mfg. Co., who were among the pioneers in the Ice-making and Refrigerating industry and who have been responsible for many of the improvements that have taken place in that line of manufacture, have this class of machinery in operation with every line of trade where artificial refrigeration is required, such as with cold storage houses, hotels, restaurants, dairies, creameries and even private houses, etc.

There is a constantly growing demand for small ice-making and refrigerating machines all over the world, and particularly so in the creameries and dairies. That this demand must necessarily result in a very large volume of business and in the specialization of this branch of the industry by the established manufacturers of ice-making and refrigerating machines is a foregone conclusion.

We designed a perfect small and closed type Vertical Single Acting Ammonia Compressor and after making the requisite test have perfected such. This machine has received very favorable consideration

by the prospective users of refrigeration in a small way, or for the production of a small quantity of ice daily. This machine has been placed on the market and a large number of them are now in daily operation in all parts of the United States and other countries.

The machine, as may be seen from the illustration, is designed for operation from any source of power, the fly-wheel being faced for belt transmission from electric motor, gas or gasoline engines, separate steam engine or steam engine on the same bed plate, or from a line shaft or such power that is most economically available where the machine is installed.

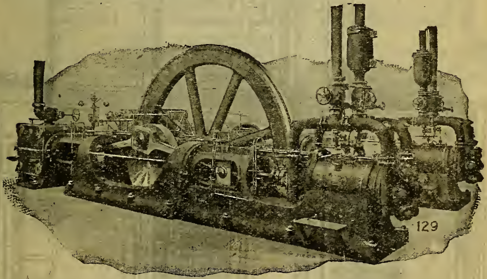
In designing this machine the company worked from the point of view of the ultimate purchaser and user, realizing that the average buyer would require, first, a machine of reasonable first cost; second, a machine of few parts and utmost simplicity; third, a machine that should be nearly automatic and practically entirely trouble-proof; and four, a machine of steady and durable construction, the last, of course, meaning the best of materials, skilled workmanship and a sufficient weight and strength to withstand the working strain at all speeds.

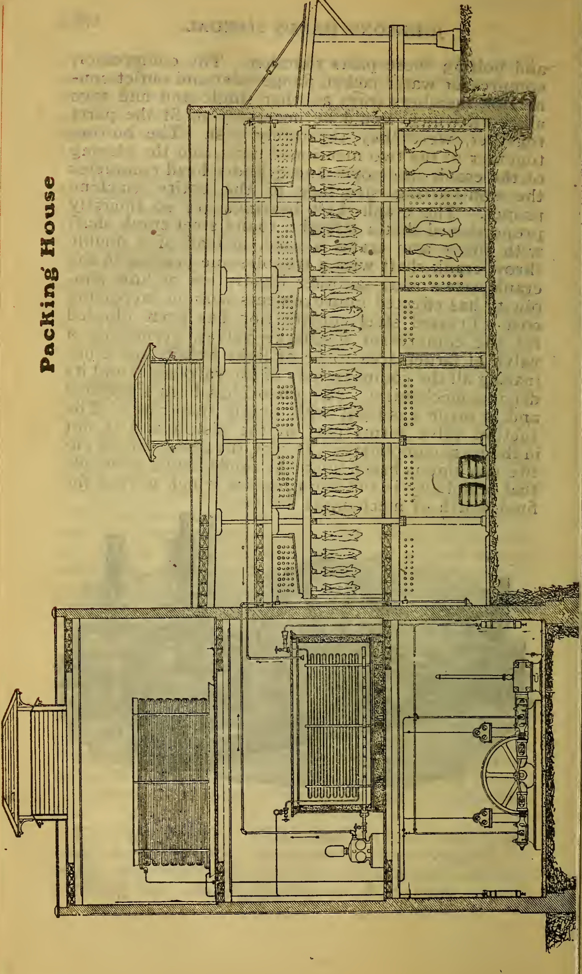
To improve upon the existing type of machinery and to reduce manufacturing costs at the same time could only be accomplished through skilled design permitting simplification and through large production, and it is entirely due to the recognition of these facts that this new and better small machine is now being produced and marketed in large numbers.

The process of simplification consisted in the elimination of every unnecessary extra part or joint requiring useless machine work for fittings and studs, nuts, bolts or cap screws for joining. The modern idea of newly construction has been employed just as far as it could be made applicable to this class of machinery, and in every instance of such application has added strength to the machine, giving it a better appearance and reduced the labor cost of construction.

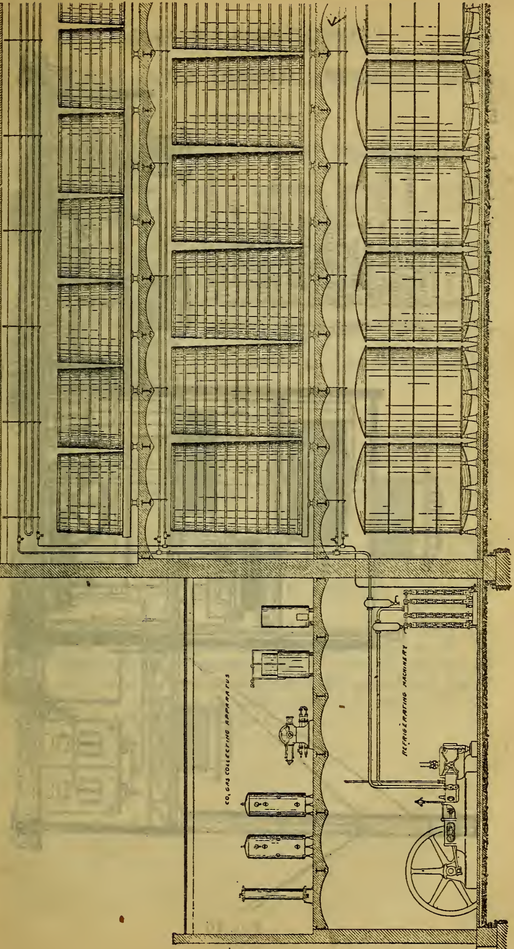
To illustrate this: The complete base, two large crank-shaft bearings, the crank case and compressor supporting riser are cast in one integral casting, avoiding the several operations of machine facing

and bolting these parts together. The compressor, compressor water jacket, flange inlet and outlet connection members form another single unit and save all work which would be necessary to fit the parts together, were they separately cast. The bolting together of the two mentioned units, and the placing of the crank case cover and cylinder head completes the non-moving structure of the entire machine proper. The crank-shaft bearings are so liberally proportioned that a straight, round steel crank shaft with single arm crank is used, instead of a double throw crank shaft with a troublesome bearing in the crank case cover,—another illustration of how simplicity has effected improvements without increasing cost. Pressed steel construction has been adopted for the compressor discharge valves, permitting a valve of larger area to be of light weight and eliminating all the complications of the valve stem and its driving mechanism. The piston has been simplified and is made gas-tight with simple snap-rings. The suction valve forms part of the piston and is not in the least complicated. In fact, the design of the entire machine is based upon the fundamental principle that simplicity is the main feature which proves the final worth of mechanical devices.





Packing House



Brewery

Arrangement of an Ice Plant.

1. Boiler.
2. Feed Pump.
3. Steam Engine.
4. Compressor.
5. Oil Trap for Ammonia.
6. Condenser.
7. Liquid Ammonia Receiver.
8. Oil Separator.
9. Purifier.
10. Steam Condenser.
11. Hot Skimmer.
12. Reboiler.
13. Cooling Coil.
14. Filters.
15. Cold Water Reservoir.
16. Filling Hose.
17. Can Filler.
18. Freezing Tank.
19. Hoist.
20. Thawing Apparatus.

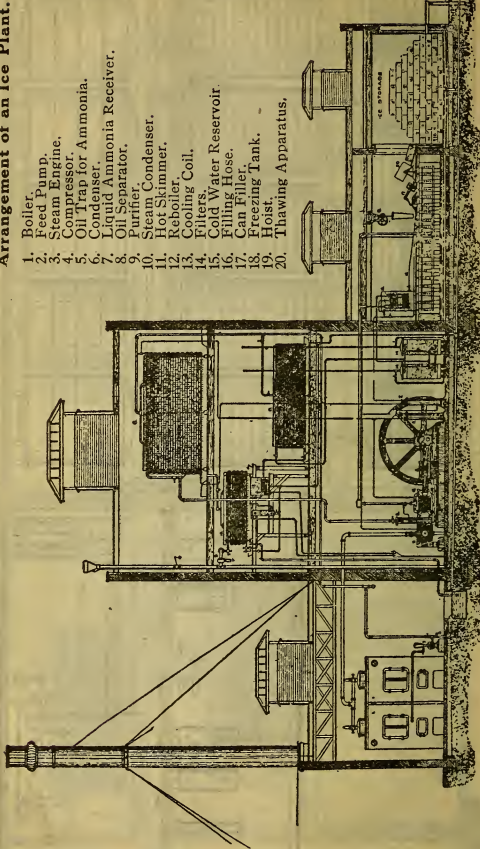


Fig. 16

GENERAL AND USEFUL INFORMATION.

Ammonia.

Ammonia is composed of one part nitrogen and three parts hydrogen.

Pure ammonia liquid is colorless, having a peculiar alkaline odor and caustic taste. It turns red litmus paper blue or white litmus paper red.

The boiling point of ammonia depends on its purity, and is about 28½° below zero at atmospheric pressure. The purer the liquid the lower its boiling point.

One pound of liquid ammonia at 32° F. will occupy 21.017 cubic feet of space when evaporated at atmospheric pressure.

The specific heat of ammonia gas as determined by Regnault is 0.50836.

Heat.

One British Thermal Unit (B. T. U.) is the quantity of heat required to raise one pound of water at 32° F. to 33° F., or the amount of heat that must be extracted from one pound of water at 33° F. to reduce it to 32° F.

The latent heat of ice is 142 B. T. U. That is to say, one pound of ice at 32° F. will require 142 B. T. U. to melt it into water at 32° F., or 142 B. T. U. must be extracted from water at 32° F. to freeze it into ice at 32° F.

One ton of refrigeration is the amount of heat absorbed by the melting of 2,000 pounds of ice at 32° F. into 2,000 pounds of water at 32° F., or the amount of heat that must be extracted from 2,000 pounds of water at 32° F. to reduce it to 2,000 pounds of ice at 32° F., or $2{,}000 \times 142 = 284{,}000$ B. T. U.

Dimensions of Vertical Compressors

Capacity Tons	Diam. and Stroke	Flywheel D. and F.	Suction and Discharge	Length Conn. Rod	Width Stuff. Box	Diam. Shaft	Floor Space L. and W. and H.	Weight Crated	Power Required	
									Elec.	Gas Eng.
¾	3 x 3¾	16 x 3½	1	10	3	1¾	23x16x35	540	2	3
1½	4 x 5¼	24 x 5	1	12½	3⅝	1¾	32x24x65	1100	3	5
3	4 x 5	24 x 5	1	12¼	4½	2½	43x24x57	1700	5	7
5	4¾ x 7	30 x 6½	1¼	17½	4⅞	3	52x30x66	2800	10	15
7	5⅝ x 8	36 x 8½	1¼	17⅜	4 15/16	3½	52x36x70	3700	15	20
10	6½ x 10	48 x 10½	1½	24⅞	5½	3⅝	61x48x90	4300	20	25
15	8 x 12	72 x 14	2	27¾	7	4 15/16	84x72x74	5900	30	35

Direct Expansion Piping.

The evaporation or expansion of the Carbonic Anhydride takes place in coils of extra heavy wrought-iron pipe. For brine tanks, water coolers, small refrigerators and rooms the pipes are welded into coils of continuous lengths and in large rooms the pipes are connected by flange unions.

Daily Capacity	Dimensions A	Dimensions B
5 tons	30 feet	56 feet
10 "	35 "	73 "
15 "	37 "	78 "
20 "	40 "	85 "
25 "	42 "	95 "
30 "	42 "	107 "
35 "	42 "	117 "
40 "	49 "	120 "
50 "	49 "	135 "
60 "	54 "	150 "
80 "	59 "	154 "
100 "	73 "	160 "

TIME REQUIRED FOR WATER TO FREEZE IN ICE CANS

Size of Cans, Inches	Weight of Cake, Pounds	Time to Freeze, Hours
6 x 12 x 24	50	20
8 x 18 x 32	100	36
8 x 16 x 40	150	36
11 x 22 x 32	200	55
11 x 22 x 44	300	60
11 x 22 x 57	400	60

NOTE—Temperature of bath 14° to 18° F. As a rule the higher the bath temperature, the slower the process of freezing, but the finer and clearer the ice.

Table Giving Number of Cubic Feet of Gas that must be Pumped per Minute at Different Condenser and Suction Pressures, to Produce One Ton of Refrigeration in Twenty-four Hours.

Temperature of Gas in Degrees F.	Corresponding Suction Pressure, Lbs. per sq. in.	Temperature of the Gas in Degrees F.								
		65°	70°	75°	80°	85°	90°	95°	100°	105°
		Corresponding Condenser Pressure (gauge), pounds per square inch.								
		103	115	127	139	153	168	184	200	218
	G. Pres.									
-27°	1	7.22	7.3	7.37	7.46	7.54	7.62	7.70	7.79	7.88
-20°	4	5.84	5.9	5.96	6.03	6.09	6.16	6.23	6.30	6.43
-15°	6	5.35	5.4	5.46	5.52	5.58	5.64	5.70	5.77	5.83
-10°	9	4.66	4.73	4.76	4.81	4.86	4.91	4.97	5.05	5.08
-5°	13	4.09	4.12	4.17	4.21	4.25	4.30	4.35	4.40	4.44
0°	16	3.59	3.63	3.66	3.70	3.74	3.78	3.83	3.87	3.91
5°	20	3.20	3.24	3.27	3.30	3.34	3.38	3.41	3.45	3.49
10°	24	2.87	2.9	2.93	2.96	2.99	3.02	3.06	3.09	3.12
15°	28	2.59	2.61	2.65	2.68	2.71	2.73	2.76	2.80	2.82
20°	33	2.31	2.34	2.36	2.38	2.41	2.44	2.46	2.49	2.51
25°	39	2.06	2.08	2.10	2.12	2.15	2.17	2.20	2.22	2.24
30°	45	1.85	1.87	1.89	1.91	1.93	1.95	1.97	2.00	2.01
35°	51	1.70	1.72	1.74	1.76	1.77	1.79	1.81	1.83	1.85

STRENGTH OF AMMONIA LIQUORS

Percentage of Ammonia by Weight	Specific Gravity	Degrees Beaume, Water 10	Degrees Beaume Water 0
0	1.000	10.0	0.0
1	0.993	11.0	1.0
2	0.986	12.0	2.0
4	0.979	13.0	3.0
6	0.972	14.0	4.0
8	0.966	15.0	5.0
10	0.960	16.0	6.0
12	0.953	17.1	7.0
14	0.945	18.3	8.2
16	0.938	19.5	9.2
18	0.931	20.7	10.3
20	0.925	21.7	11.2
22	0.919	22.8	12.3
24	0.913	23.9	13.2
26	0.907	24.8	14.3
28	0.902	25.7	15.2
30	0.897	26.6	16.2
32	0.892	27.5	17.3
34	0.888	28.4	18.2
36	0.884	29.3	19.1
38	0.880	30.2	20.0

TABLE OF BRINE SOLUTION

(Chloride of Sodium—Common Salt)

Percentage of Salt by weight	Degrees on Salometer at 60 Degrees F.	Specific Gravity at 60 Degrees F.	Specific Heat	Weight of 1 Gallon	Pounds of Salt in 1 Gallon	Pounds of Water in 1 Gallon	Weight of 1 Cubic Foot	Pounds of Salt in 1 Cubic Foot	Pounds of Water in 1 Cubic Foot	Freezing Point Degrees F.
0	0	1.	1.	8.35	0.	8.35	62.4	0.	62.4	32.
1	4	1.007	0.992	8.4	0.084	8.316	62.8	0.628	62.172	31.8
5	20	1.037	0.96	8.65	0.432	8.218	64.7	3.237	61.465	25.4
10	40	1.073	0.892	8.95	0.895	8.055	66.95	6.695	60.253	18.6
15	60	1.115	0.855	9.3	1.395	7.905	69.57	10.435	59.134	12.2
20	80	1.150	0.829	9.6	1.92	7.68	71.76	14.352	57.408	6.86
25	100	1.191	0.783	9.94	2.485	7.455	74.26	18.565	55.695	1.00

CORRECTION FOR TEMPERATURE OF AQUA AMMONIA

The figures in top row indicate degrees Fahrenheit; those in the columns beneath give the strength of Ammonia at 60°

Degrees Beaume	60°	66°	67°	68°	72°	74°	76°	78°	81°	84°	88°	90°	92°	95°	96°	100°	102°	108°	109°
18	18	.....	.....	17¾	.....	.....	17½	.....	.....	17¼	.....	.....	17	.....	.....	16¾	.....	16½	.....
18¼	18¼	.....	.....	18	.....	.....	17¾	.....	.....	17½	.....	.....	17¼	.....	.....	17	.....	16¾	.....
18½	18½	.....	.....	18¼	.....	.....	18	.....	.....	17¾	.....	.....	17½	.....	.....	17¼	.....	17	.....
18¾	18¾	.....	.....	18½	.....	.....	18¼	.....	.....	18	.....	.....	17¾	.....	.....	17½	.....	17¼	.....
19	19	.....	.....	18¾	.....	.....	18½	.....	.....	18¼	.....	.....	18	.....	.....	17¾	.....	17½	.....
19¼	19¼	.....	.....	19	.....	.....	18¾	.....	.....	18½	.....	.....	18¼	.....	.....	18	.....	17¾	.....
19½	19½	.....	.....	19¼	.....	.....	19	.....	.....	18¾	.....	.....	18½	.....	.....	18¼	.....	18	.....
19¾	19¾	.....	.....	19½	.....	.....	19¼	.....	.....	19	.....	.....	18¾	.....	.....	18½	.....	18¼	.....
20	20	.....	19¾	.....	.....	19½	.....	.....	19¼	.....	19	.....	.....	18¾	.....	.....	18½	.....	18¼
20¼	20¼	.....	20	.....	.....	19¾	.....	.....	19½	.....	19¼	.....	.....	19	.....	.....	18¾	.....	18½
20½	20½	.....	20¼	.....	.....	20	.....	.....	19	.....	19½	.....	.....	19¼	.....	.....	19	.....	18¾
20¾	20¾	.....	20½	.....	.....	20¼	.....	.....	20½	.....	19¾	.....	.....	19½	.....	.....	19¼	.....	19
21	21	.....	20¾	.....	.....	20½	.....	.....	20¾	.....	20	.....	.....	19¾	.....	.....	19½	.....	19¼
21¼	21¼	.....	21	.....	.....	20¾	.....	.....	20¾	.....	20¼	.....	.....	20	.....	.....	19¾	.....	19½
21½	21½	.....	21¼	.....	.....	21	.....	.....	20	.....	20½	.....	.....	20¼	.....	.....	20	.....	19¾
21¾	21¾	.....	21½	.....	.....	21¼	.....	.....	21	.....	20¾	.....	.....	20½	.....	.....	20¼	.....	20
22	22	21¾	.....	.....	21½	.....	.....	21¼	.....	21	.....	20¾	.....	.....	20½	.....	20¼	20	.....
22¼	22¼	22	.....	.....	21¾	.....	.....	21½	.....	21¼	.....	21	.....	.....	20¾	.....	20½	20¼	.....
22½	22½	22¼	.....	.....	22	.....	.....	21¾	.....	21½	.....	21¼	.....	.....	21	.....	20¾	20½	.....
22¾	22¾	22½	.....	.....	22¼	.....	.....	22	.....	21¾	.....	21½	.....	.....	21¼	.....	21	20¾	.....
23	23	22¾	.....	.....	22½	.....	.....	22¼	.....	22	.....	21¾	.....	.....	21½	.....	21¼	21	.....
23¼	23¼	23	.....	.....	22¾	.....	.....	22½	.....	22¼	.....	22	.....	.....	21¾	.....	21½	21¼	.....
23½	23½	23¼	.....	.....	23	.....	.....	22¾	.....	22½	.....	22¼	.....	.....	22	.....	21¾	22½	.....

CORRECTION FOR TEMPERATURE OF AQUA AMMONIA—Continued

The figures in top row indicate degrees Fahrenheit: those in the columns beneath give the strength of Ammonia at 60°

Degrees Beaume	60°	64°	65°	68°	70°	72°	75°	76°	80°	84°	85°	88°	90°	92°	95°	96°	100°	104°	105°
23¾	23¾	.....	23½	.....	23¼	.....	23	.....	22¾	.....	22½	.....	22¼	.....	22	.....	21¾	.....	21½
24	24	.....	23¾	.....	23½	.....	23¼	.....	23	.....	22¾	.....	22½	.....	22¼	.....	22	.....	21¾
24¼	24¼	.....	24	.....	23¾	.....	23½	.....	23¼	.....	23	.....	22¾	.....	22½	.....	22¼	.....	22
24½	24½	.....	24¼	.....	24	.....	23¾	.....	33½	.....	23¼	.....	23	.....	22¾	.....	22½	.....	22¼
24¾	24¾	.....	24½	.....	24¼	.....	24	.....	23¾	.....	23½	.....	23¼	.....	23	.....	22¾	.....	22½
25	25	.....	24¾	.....	24½	.....	24¼	.....	24	.....	23¾	.....	23½	.....	23¼	.....	23	.....	22¾
25¼	25¼	.....	25	.....	24¾	.....	24½	.....	24¼	.....	24	.....	23¾	.....	23½	.....	23¼	.....	23
25½	25½	25¼	.....	25	.....	24¾	.....	24½	24¼	24	.....	23¾	.....	23½	.....	23¼	23	22¾	.....
25¾	25¾	25½	.....	25¼	.....	25	.....	24¾	24½	24¼	.....	24	.....	23¾	.....	23½	23¼	23	.....
26	26	25¾	.....	25½	.....	25¼	.....	25	24¾	24½	.....	24¼	.....	24	.....	23¾	23½	23¼	.....
26¼	26¼	26	.....	25¾	.....	25½	.....	25¼	25	24¾	.....	24½	.....	24¼	.....	24	23¾	23½	.....
26½	26½	26¼	.....	26	.....	25¾	.....	25½	25¼	25	.....	24¾	.....	24½	.....	24¼	24	23¾	.....
26¾	26¾	26½	.....	26¼	.....	26	.....	25¾	25½	25¼	.....	25	.....	24¾	.....	24½	24¼	24	.....
27	27	26¾	.....	26½	.....	26¼	.....	26	25¾	25½	.....	25¼	.....	25	.....	24¾	24½	24¼	.....
27¼	27¼	27	.....	26¾	.....	26½	.....	26¼	26	25¾	.....	25½	.....	25¼	.....	25	24¾	24½	.....
27½	27½	27¼	.....	27	.....	26¾	.....	26½	26¼	26	.....	25¾	.....	25½	.....	25¼	25	24¾	.....
27¾	27¾	27½	.....	27¼	.....	27	.....	26¾	26½	26¼	.....	26	.....	25¾	.....	25½	25¼	25	.....
28	28	27¾	.....	27½	.....	27¼	.....	27	26¾	26½	.....	26¼	.....	26	.....	25¾	25½	25¼	.....

The specific gravity of Aqua Ammonia changes with the temperature at which it is measured with the hydrometer. The readings are too high if the temperature of the Ammonia is over 60° F., and too low if under. In order to ascertain the exact strength of Ammonia at 60° F. make corrections for temperature in accordance with the table above, thus: 26½° Ammonia measured at a temperature of 80° F., is equal to 25¼° Ammonia at a temperature of 60° F.

TABLE OF CHLORIDE OF CALCIUM SOLUTION

Specific Gravity at 64 Degrees F.	Degree Beaume at 64 Degrees F.	Degree Salometer at 64 Degrees F.	Per Cent of $CaCl_2$	Freezing Point in Degrees F.	Ammonia Gauge Pressure Pounds per Square Inch.
1.007	1	4	0.943	+31.20	46
1.014	2	8	1.886	+30.40	45
1.021	3	12	2.829	+29.60	44
1.028	4	16	3.772	+28.80	43
1.035	5	20	4.715	+28.00	42
1.043	6	24	5.658	+26.89	41
1.050	7	28	6.601	+25.78	40
1.058	8	32	7.544	+24.67	38
1.065	9	36	8.487	+23.56	37
1.073	10	40	9.430	+22.09	35.5
1.081	11	44	10.373	+20.62	34
1.089	12	48	11.316	+19.14	32.5
1.097	13	52	12.259	+17.67	30.5
1.105	14	56	13.202	+15.75	29
1.114	15	60	14.145	+13.82	27
1.112	16	64	15.088	+11.89	25
1.131	17	68	16.031	+ 9.96	23.5
1.140	18	72	16.974	+ 7.68	21.5
1.149	19	76	17.917	+ 5.40	20
1.158	20	80	18.860	+ 3.12	18
1.167	21	84	19.803	− 0.84	15
1.176	22	88	20.746	− 4.44	12.5
1.186	23	92	21.689	− 8.03	10.5
1.196	24	96	22.632	−11.63	8
1.205	25	100	23.575	−15.23	6
1.215	26	104	24.518	−19.56	4
1.225	27	108	25.461	−24.43	1.5
1.236	28	112	26.404	−29.29	1 in. vacuum
1.246	29	116	27.347	−35.30	5 " vacuum
1.257	30	120	28.290	−41.32	8.5 " vacuum
1.268	31	...	29.233	−47.66	12 " vacuum
1.279	32	...	30.176	−54.00	15 " vacuum
1.290	33	...	31.119	−44.32	10 " vacuum
1.302	34	...	32.062	−34.66	4 " vacuum
1.313	35	...	33.	−25.00	1.5 pounds

HORSE POWER REQUIRED TO COMPRESS ONE CUBIT FOOT OF AMMONIA PER MINUTE

Condenser Pressure and Temperature

p	103	115	127	139	153	168	184	200	218
t	65°	70°	75°	80°	85°	90°	95°	100°	105°
− 20°	.1809	.1916	.2022	.2128	.2235	.2342	.2448	.2554	.2661
− 15°	.1864	.1980	.2097	.2214	.2330	.2447	.2563	.2679	.2796
− 10°	.1937	.2067	.2196	.2325	.2454	.2583	.2712	.2842	.2971
− 5°	.2001	.2144	.2287	.2430	.2573	.2716	.2859	.3002	.3145
0°	.2048	.2206	.2363	.2521	.2679	.2836	.2994	.3151	.3309
5°	.2083	.2257	.2430	.2604	.2778	.2952	.3125	.3299	.3473
10°	.2096	.2286	.2477	.2667	.2858	.3048	.3239	.3429	.3620
15°	.2089	.2298	.2506	.2715	.2924	.3133	.3342	.3551	.3760
20°	.2054	.2282	.2510	.2738	.2966	.3195	.3423	.3651	.3879
25°	.1992	.2240	.2489	.2738	.2987	.3226	.3485	.3734	.3983
30°	.1897	.2169	.2440	.2711	.2982	.3253	.3524	.3795	.4066
35°	.1768	.2062	.2357	.2651	.2946	.3241	.3535	.3830	.4124

NOTE—These figures do not allow for friction.

COMPARISON OF THERMOMETERS

Cent.	Reau.	Fahr.	Cent.	Reau.	Fahr.	Cent.	Reau.	Fahr.
—40	—32.0	—40.0	21	16.8	69.8	62	49.6	143.6
—38	—30.4	—36.4	22	17.6	71.6	63	50.4	145.4
—36	—28.8	—32.8	23	18.4	73.4	64	51.2	147.2
—34	—27.2	—29.2	24	19.2	75.2	65	52.0	149.0
—32	—25.6	—25.6	25	20.0	77.0	66	52.8	150.8
—30	—24.0	—22.0	26	20.8	78.8	67	53.6	152.6
—28	—22.4	—18.4	27	21.6	80.6	68	54.4	154.4
—26	—20.8	—14.8	28	22.4	82.4	69	55.2	156.2
—24	—19.2	—11.2	29	23.2	84.2	70	56.0	158.0
—22	—17.6	— 7.6	30	24.0	86.0	71	56.8	159.8
—20	—16.0	— 4.0	31	24.8	87.8	72	57.6	161.6
—18	—14.4	— 0.4	32	25.6	89.6	73	58.4	163.4
—16	—12.8	+ 3.2	33	26.4	91.4	74	59.2	165.2
—14	—11.2	6.8	34	27.2	93.2	75	60.0	167.0
—12	— 9.6	10.4	35	28.0	95.0	76	60.8	168.8
—10	— 8.0	14.0	36	28.8	96.8	77	61.6	170.6
— 8	— 6.4	17.6	37	29.6	98.6	78	62.4	172.4
— 6	— 4.8	21.2	38	30.4	100.4	79	63.2	174.2
— 4	— 3.2	24.8	39	31.2	102.2	80	64.0	176.0
— 2	— 1.6	28.4	40	32.0	104.0	81	64.8	177.8
0	0.0	32.0	41	32.8	105.8	82	65.6	179.6
+ 1	+ 0.8	33.8	42	33.6	107.6	83	66.4	181.4
2	1.6	35.6	43	34.4	109.4	84	67.2	183.2
3	2.4	37.4	44	35.2	111.2	85	68.0	185.0
4	3.2	39.2	45	36.0	113.0	86	68.8	186.8
5	4.0	41.0	46	36.8	114.8	87	69.6	188.6
6	4.8	42.8	47	37.6	116.6	88	70.4	190.4
7	5.6	44.6	48	38.4	118.4	89	71.2	192.2
8	6.4	46.4	49	39.2	120.2	90	72.0	194.0
9	7.2	48.2	50	40.0	122.0	91	72.8	195.8
10	8.0	50.0	51	40.8	123.8	92	73.6	197.6
11	8.8	51.8	52	41.6	125.6	93	74.4	199.4
12	9.6	53.6	53	42.4	127.4	94	75.2	201.2
13	10.4	55.5	54	43.2	129.2	95	76.0	203.0
14	11.2	57.2	55	44.0	131.0	96	76.8	204.8
15	12.0	59.0	56	44.8	132.8	97	77.6	206.6
16	12.8	60.8	57	45.6	134.6	98	78.4	208.4
17	13.6	62.6	58	46.4	136.4	99	79.2	210.2
18	14.4	64.4	59	47.2	138.2	100	80.0	212.0
19	15.2	66.2	60	48.0	140.0			
20	16.0	68.0	61	48.8	141.8			

Freezing point on Fahrenheit scale is +32 degrees; boiling point, 212 degrees.

Freezing point on Centigrade scale is +0 degrees; boiling point, 100 degrees.

Freezing point on Reaumur scale is +0 degrees; boiling point, 80 degrees.

Of water at sea level at normal barometer pressure (29.9 inch).

The "absolute zero" of temperature denotes that condition of matter at which heat ceases to exist. At this point a body would be wholly deprived of heat and a gas would exert no pressure.

The absolute zero on the Fahrenheit scale is about 461 degrees below zero.

The absolute zero on the Centigrade scale is about 274 degrees below zero.

The absolute zero on the Reaumur scale is about 219 degrees below zero.

An English unit of heat (B. T. U.) is the quantity required to raise one pound of Water one degree Fahrenheit. A metric unit of heat or metric caloric (M. C.) is the quantity of heat required to raise one litre of water one degree centigrade.

GENERAL DIMENSIONS IN FEET FOR ICE MAKING PLANTS

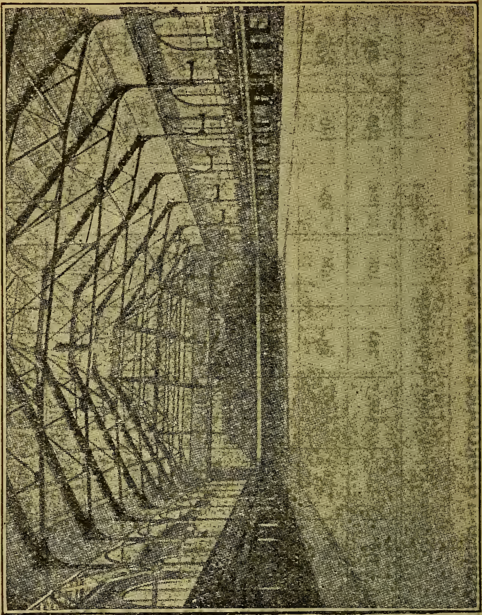
Capacity Tons Ice	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R	S	T
2	47	28	17	10	18	10	10	28	12	8	18	16	20	6	9	16	5	12	10
5	48	42	17	10	32	10	10	42	13	8	32	16	20	6	9	16	5	12	10
8	61	34	19	12	24	12	10	34	22	8	24	16	20	6	10	16	5	12	10
10	72	34	21	15	24	15	10	34	26	10	24	16	20	6	10	16	5	12	10
12	72	38	21	15	28	15	10	38	26	10	28	16	20	6	10	16	5	12	10
15	78	44	24	18	34	18	10	44	26	10	34	16	20	6	12	20	5	12	10
18	80	50	24	18	40	18	10	50	26	12	40	16	20	6	12	20	5	12	10
20	87	46	25	18	36	18	10	46	32	12	36	16	22	6	12	20	5	12	10
25	89	54	25	20	44	20	10	54	32	12	44	16	22	6	12	20	5	12	10
30	92	62	25	20	50	20	12	62	32	15	52	16	22	6	12	20	5	12	10
35	93	70	26	20	58	20	12	70	32	15	60	16	22	6	12	22	5	12	10
40	93	79	26	20	67	20	12	79	32	15	69	16	22	6	12	22	5	12	10
50	144	54	35	25	39	25	15	54	64	20	44	20	22	6	12	24	5	12	10
60	145	62	36	25	47	25	15	62	64	20	52	20	25	6	12	24	5	12	10
75	160	79	46	30	64	30	15	79	64	20	69	20	25	6	12	27	5	12	10
100	173	95	54	30	80	30	15	95	64	25	85	20	25	6	12	30	5	12	10
150	247	95	76	40	80	30	15	95	96	35	85	20	25	6	12	30	5	12	10
200	333	95	100	40	80	30	15	95	128	45	85	20	25	6	12	30	5	12	10

HORSE POWER REQUIRED TO PRODUCE ONE TON OF REFRIGERATION

Condenser Pressure and Temperature

Refrigerator Pressure and Temp. p	t \ p	103	115	127	139	153	168	184	200	218
p	t	65°	70°	75°	80°	85°	90°	95°	100°	105°
4	−20°	1.0584	1.1304	1.2051	1.2832	1.3611	1.4427	1.5251	1.6090	1.6910
6	−15°	.9972	1. 692	1.1450	1.2221	1.3001	1.4101	1.4609	1.5458	1.7300
9	−10°	.9026	.9777	1.0453	1.1183	1.1926	1.2602	1.3471	1.4352	1.5093
13	−5°	.8184	.8833	.9537	1.0230	1.0935	1.1679	1.2437	1.3209	1.3964
16	0°	.7352	.8008	.8648	.9328	1.0019	1.0718	1.1467	1.2194	1.2547
20	5°	.6665	.7312	.7946	.8593	.9278	.9978	1.0656	1.1381	1.2121
24	10°	.5915	.6629	.7257	.7894	.8545	.9205	.9911	1.0595	1.1294
28	15°	.5410	.5998	.6641	.7276	.7924	.8553	.9224	.9943	1.0603
33	20°	.4745	.5340	.5923	.6716	.7148	.7796	.8420	.9031	.9736
39	25°	.4103	.4659	.5227	.5804	.5992	.7022	.7667	.8289	.8922
45	30°	.3509	.4056	.4612	.5178	.5755	.6353	.6944	.7590	.8172
51	35°	.3005	.3546	.4101	.4666	.5214	.5804	.6398	.7009	.7629

NOTE—The figures in this table represent the minimum theoretical amount. In practice they must be increased about 50 per cent.



Artificial Ice-Skating Rinks

Artificial skating rinks should be in connection with cold storage or ice making plants. This makes a fine investment the year around. On all sides Delavergne Machine Co. of New York has the far been the most successful on the biggest skating rinks in the United States and has quite a number in operation all over this country and Canada. Coils in the rink floor are usually made of inch and quarter

pipe. They run either way, lengthwise or crosswise of the rink floor. In this one rink the coils are shown running lengthwise. In either case inlet and outlet headers are provided which are simply manifolds with a connection for each inch and a quarter pipe. Each coil is usually provided with inlet valve and outlet valve so that each can be cut off from the rest if necessary.

For cooling the brine, one of two methods is generally employed. In one case there is provided a large steel tank in which direct expansion ammonia coils are submerged in the brine, similar to the freezing tank of an ice plant. The other arrangements consists of the use of a brine cooler of the shell and tube type which resembles very much a horizontal tubular steam boiler. The brine passes through the tubes, making several passes, while the ammonia is on the inside of the shell and evaporates there, producing the cooling effect. In connection with this latter type of cooler, it is necessary to use a small tank known as a balancing or compensating tank, since the volume of brine contained in the cooler is rather small, and it is necessary to have this tank in order to provide for a larger amount.

For circulating the brine through the coils, usually a centrifugal pump is used when electric power is used for driving the plant. The electric motor is direct connected to the pump, and in connection with the shell cooler, the section of the pump is connected to the balance of the tank and the discharge leads to the cooler and from there to the coils. In case the plant is steam-driven, an ordinary direct connected Duplex steam pump could be used, although this type is very economical in the use of steam.

Freezing System.

There are two standard systems of cooling and freezing. We refer to the brine system and the direct expansion system. The direct expansion system provides for the direct expansion of ammonia in pipes whch are located directly in the rooms, chambers, tanks or whatever must be refrigerated. With the brine system, the ammonia is first expanded to cool a strong solution of salt or calcium brine which is circulated in the various rooms or chambers or tanks.

In the first system there is only one medium, while in the second system there are two mediums. This means an additional step, which reduces the economy. Therefore, the direct expansion system affords better economy.

In skating rinks, however, the use of the direct expansion system would be entirely impractical. The reason lies in the absolute necessity of freezing a smooth and even surface. On account of the length of the cooling coils which must be used for freezing such a surface, it would be impossible to regulate the direct expansion of ammonia in any manner to give good results.

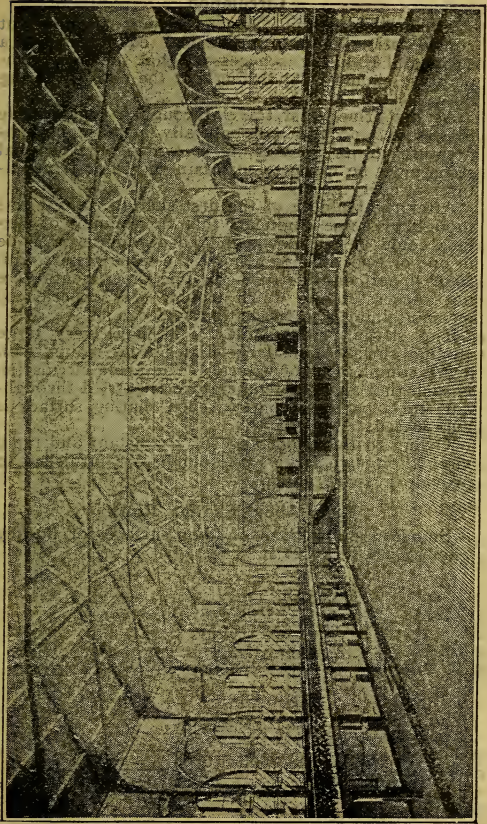
Our Experience

The first artificial ice-skating rink in the United States was erected by us in New York City about twenty years ago. We refer to the well-known St. Nicholas Skating Rink, which has been in constant operation since that time.

With no other rinks to copy from, our engineers were compelled to make original designs in building the St. Nicholas Rink. The success of the plant was quite remarkable and only one difficulty was encountered after the rink started in operation.

It was found that considerable snow accumulated on the surface after each session, and to remove it, a mechanical scraper was experimented with, but proved to be impractical. After a short time, the trouble was overcome by removing the snow with artificial hand scrapers or a planer drawn by a donkey.

After the snow is removed, the surface is flooded with a thin film of water and then refrozen for the next session.



Floor of St. Nicholas Skating Rink, showing pipes before flooding

Circulation

The brine circulating system is the most important consideration in the mechanical equipment of a successful rink. It is necessary that the same temperature should exist throughout the entire freezing floor.

As the brine must travel through a considerable length of pipe and will naturally increase in temperature in its passage, it is evident that special steps must be taken to maintain the same temperatures at every point.

After the building of the first skating rink, it was though by some engineers that the amount of surface could be cut down and an attempt was made in one or two rinks to achieve the same results with 30 or 40 per cent less surface. The experiments were not successful and much trouble was experienced in maintaining a good skating surface.

The skating rinks built by us have very large cooling surfaces and large distributing mains, with a full complement of valves. The brine circulation is such that an even temperature is carried throughout and a perfectly smooth even skating surface is guaranteed.

Owing to the importance of a constant and rapid circulation, two large brine pumps are furnished to provide a spare unit.

Facts About Skating Rinks

Standard dimensions of floor surface for hockey games: 200 ft. by 85 ft.

Approximate number of persons which can skate on rink of standard size at one time: From 500 to 600.

Usual admission charge for skating: 25 to 50 cents per session.

Usual admission charge during hockey matches: Standing room, 50c. to $1.00; seats, 75c. to $2.00; box seats, $1.50 to $3.00, depending upon size of city and representation of the hockey teams playing.

Usual period of skating session: From October 1st to April 1st.

Usual number of skating sessions per day: Three —First session from 10 A. M. to 12:30 P. M.; Second session from 2:30 to 5 P. M.; Third session from 8 to 10:30 P. M.

Standard system of freezing floor surface: Brine circulation.

Approximate total refrigerating capacity of machines necessary for standard skating rinks: 100 tons every 24 hours, preferably in two units of 50 tons each.

Approximate ice-making capacity of same machines: 50 tons every 24 hours.

Approximate dimensions of building: 250 ft. long by 150 ft. wide or equivalent.

Approximate size of arena room: 225 ft. by 125 ft.

Approximate size of engine room: 40 ft. by 40 ft.

Approximate size of 50-ton freezing tank room: 50 ft. by 100 ft.

Operating force, engine room: 1 Chief Engineer, 2 Assistant Engineers, 2 Firemen (if boilers are used).

Office force: 1 Manager, 1 Bookkeeper.

Attendants (approximate): 1 Ticket Seller, 1 Ticket Collector, 2 men to distribute skates, 1 maid, 1 coat room boy, 2 or 3 instructors, 3 or 4 attendants to put skates on, suitable band of music, 2 or 3 cleaners.

Floor Surface

The standard size of skating rinks for hockey games is now understood to be about 200 feet in length and about 85 feet in width. Some of the surfaces are slightly smaller, but these dimensions are recommended. For rough calculations, it can

be assumed that for comfortable skating, about 30 square feet should be allowed for each person.

In other words, if a rink has 18,000 square feet, it will accomodate about 600 people at one time and not be over-crowded. The attendance may be larger than this precise number because there will always be a certain percentage coming, going and resting.

Machinery Equipment

The most practical arrangement of the refrigerating plant is to have two units. Both machines must be operated when freezing the surface and then one machine is usually sufficient to maintain it. Two machines, each of a refrigerating capacity of 50 tons every 24 hours are ample for taking care of the standard skating rink, the dimensions of which have already been given.

These two machines would also be capable of operating an ice-making plant of 50 tons daily capacity when the skating surface is not required. Such a plant is a good commercial size and can be operated with profit in any city where a skating rink might be located to advantage.

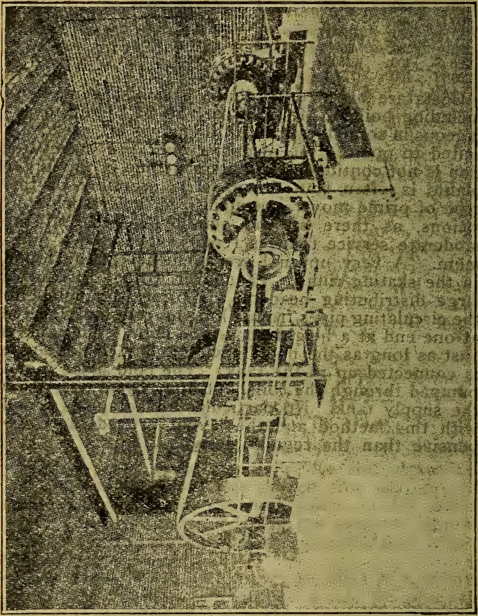
If only one machine is used, it can be of 75 tons refrigerating capacity, as this size would be sufficient to freeze the surface, although it would require a longer period to do the work than two 50-ton machines.

Two machines are surely the better layout, since they not only make it possible to shut down one unit when the surface is frozen, but also provide ample capacity to freeze the surface quickly and to manufacture 50 tons of ice in the summer months. Moreover, two units are always an advantage in case of accidents.

There may be situations where rinks of a smaller size than the standard surface would be practical, but it is doubtful if the surface could be any less than 13,000 or 14,000 square feet and offer any pleasure to skaters. It is essential to have about 150 feet in length and 80 or 90 feet in width, in order that the patrons will have room to skate without too many turns.

SURFACE Length	Width	Total Sq. feet	No. of Machines	Total Refrigerating Capacity per 24 hours	Estimated first cost complete mechanical equipment
100	50	5000	1	30 tons	$15,000.
100	80	8000	1	50 "	21,000.
150	80	12000	2	70 "	30,000.
200	80	16000	2	100 "	37,500.
250	100	25000	2	140 "	51,000.
300	100	30000	2	160 "	60,000.

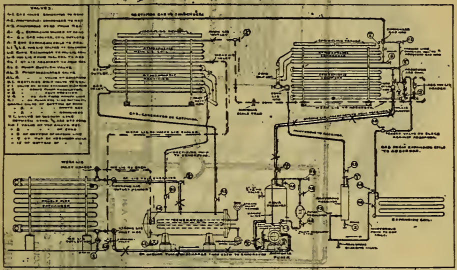
Costs are based on ordinary steam driven plants including boiler. Motor drive will be found advantageous in some localities. Oil engines are especially suited to operate the machinery because the operation is not continuous and one machine in the larger plants is often shut down. The economy of this type of prime mover is emphasized under such conditions, as there are no standby losses and the moderate service reduces repair expense to a minimum. A very unusual arrangement can be found in the skating rink in Vancouver, B. C. Instead of large distributing headers, the brine is supplied to the circulating pipes from a long narrow tank located at one end at a height above the floor. The tank is just as long as the floor is wide and each floor pipe is connected up to the tank. The cold brine is not pumped through the coils, but flows by gravity from the supply tank. No particular advantage is found with this method and the layout proved more expensive than the regular design.



Engine Room, St. Nicholas Skating Rink, New York City; two motor-driven "De La Vergne" Machines

For Plant Owners and Operators of Absorption Machines This Sketch of The New Atmospheric Type Carbondale Refrigerating Machine and Connections is Valuable.

Ammonia Gas Connections between parts of apparatus are shown by SOLID LINES.
Ammonia Gas in weak solution with water, known as Weak Aqua Liquor shown by BROKEN LINES.
Ammonia Gas in strong solution with water, known as Strong Aqua Liquor, shown by DOUBLE LINES.



NOTES—Pure ammonia liquid boils at 28½° below zero (Fahr.). Water boils at 212° Fahr. above zero. A mixture of ammonia and water will have a boiling point somewhere between these two temperatures, depending on the strength of the aqua ammonia solution. Roughly, a pound of steam condensed in the generator coils will distill from ammonia liquor a pound of ammonia gas. Approximately 26 lbs. of anhydrous ammonia must be discharged into the condenser by any refrigerating machine per hour per ton of refrigerating effect. The ammonia liquor circulating pump must handle approximately 120 cubic inches of strong liquor per minute per ton of work done. Aqua ammonia is employed in the absorption machine as a conveyor, transferring continuously the used charge of ammonia gas to the generator, to be distilled, reliquefied and used again in the expansion chamber.

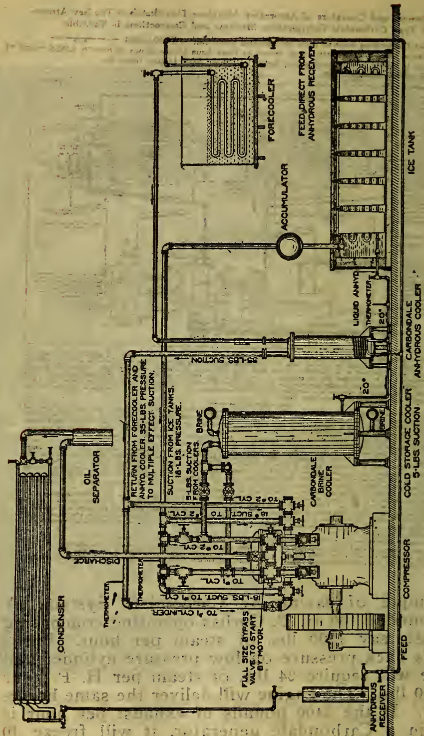
The operation of any Carbondale Absorption Type Refrigerating Machine is based on the fact that pure water readily absorbs, and holds in solution, ammonia gas. The quantity of ammonia it will absorb and hold depends only on the efficiency of the mixing device, the pressure of the gas and the temperature of the solution of aqua ammonia. Strong solution aqua ammonia is pumped through the exchanger into the generator. Steam coils heat the solution and drive out the ammonia gas, which is passed through the rectifier or moisture separator, into the condenser. This operation is similar to the discharge stroke of the compression machine and accomplishes the same result, and the same number of pounds of high pressure ammonia gas must be discharged into the condenser, cooled and liquefied per hour per ton of refrigerating effect. It is then conducted to the expansion coils through the feed valve, where it is allowed to evaporate, as in the compression system gathering heat from the objects to be refrigerated. Since strong aqua liquor is being continually pumped into the generator and the gas driven off to the condenser a continuous supply of weak liquor results, which passes out of the generator, through the exchanger and weak liquor cooler to the absorber, through a regulating valve for a fresh charge of ammonia gas. The weak liquor enters the absorber through an injector device, drawing gas from the cooler and absorbing it and this process compares with the suction stroke of a compressor. The resultant strong aqua ammonia is taken from the absorber by the aqua pump and forced through the exchanger heater to the generator. The steam coils heat the liquor, distilling off the gas and the process is repeated continually.

The above information is of educational value and interest to owners and operators who wish to learn the method of operation by which their machine produces refrigeration. For the experienced engineer this sketch will simplify the breaking in of green operators. Frame this diagram and reading matter under glass where it may be consulted frequently by the operator, who should in a short time be able to locate corresponding lines in the plant. If the valves in your plant are similarly lettered and marked it will help the engineers and in case of a fire or break, the valves already being familiar, the necessary ones closed promptly, thereby ammonia losses and other damage prevented. We can furnish marked metal tags at small cost.

When writing for information, if we know you have this diagram, it will greatly simplify our instructions.

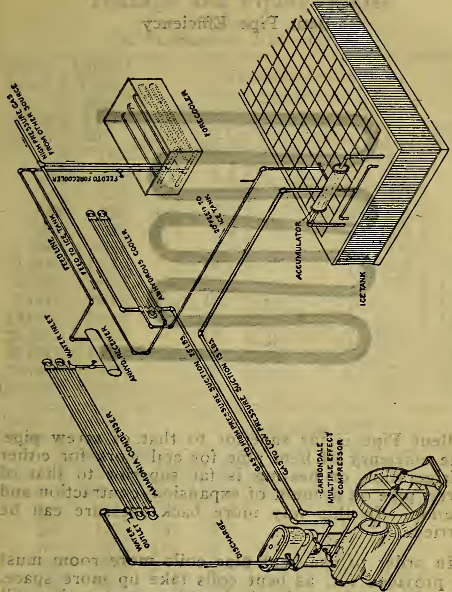
Keep A Log of Operation, Coal, Repairs and Results.
Keep your anhydrous receiver outlet sealed always.
Keep your generator coils covered with aqua always.
Keep your generator steam pressure as uniform as possible.
Slow ammonia piston speed means long rod and packing life.
Clean pipe surfaces, mean lower operating costs and greater capacity.

Example of saving by Carbondale System. A compounded 100 H. P. Corliss operating condensing will use, say 1800 lbs. of steam per hour. Put 3 pounds back pressure on low pressure cylinder and engine will require 24 lbs. of steam per H. P. hour or 2400 lbs. The engine will deliver the same horsepower. If the 2400 pounds of exhaust per hour is used in a Carbondale generator, it will freeze 40 tons of water to ice per day. This ice will increase the steam consumption of the engine 600 lbs. per hour or 14,400 lbs. per day. Assume steam costs 40c per 1000 lbs, 40 tons of ice will require less than $6.00 worth of additional steam.



CARBONDALE MULTIPLE EFFECT SYSTEM AS APPLIED TO ICE MAKING & COLD STORAGE

3 TEMPERATURES



CARBONDALE MULTIPLE EFFECT SYSTEM AS APPLIED TO ICE MAKING

Cubic feet displaced by different size ice cans.

Ice Cake	Size Ice Cans Size	Displace brine in ice Tank
100 lbs.	8 x16 x32	1.6 cu. ft.
200 "	11½x22½x32	3.2 " "
300 "	11½x22½x44	5.0 " "
400 "	11½x22½x57	6.5 " "

For Direct Expansion Coils in ice tank-top feed allow 300 lineal feet of 1¼-inch pipe.

For flooded coils properly designed and not over 350 feet of 1¼-inch pipe per coil allow 220 lineal feet per ton of ice capacity.

Bent Pipe Efficiency

Bent Pipe is far superior to that of screw pipe. The efficiency of bent pipe for coil work for either refrigeration or heating is far superior to that of screw pipe on account of expansion, contraction and friction. In this way more back pressure can be carried.

In order to use bent pipe coils more room must be provided for, as bent coils take up more space. The shortest bend that inch and a quarter pipe will stand is 4 inches, center to center. This is the size that is ordinarily used on small work, such as creameries, butcher shops and hotels. Two inch pipe would take up a great deal of room. That is for refrigeration work like cold storage and ice storage for ice-making plants. But it pays and saves money in the long run to use bent pipe coils, doing away with leaks entirely.

Tonnage and Piping Tables

Cu. Ft. Space to 1 Ft. of Pipe.

Cubic Space in Box or Room	Cubic Foot per Ton Ref.	Temperature 40°F					
		Direct Exp.			Brine †		
		1-in.	1¼-in.	2-in.	1-in.	1¼-in.	2-in.
12	150	3.	5.		2.5	4.	
20	185	3.1	5.1		2.6	4.1	
50	225	3.2	5.2		2.7	4.2	
100	300	3.4	5.5		2.8	4.4	
250	500		6.3			4.8	
500	850		7.5			5.6	
1,000	1200		8.7			6.4	9.5
3,000	1600		10.			7.3	11.
5,000	2300		12.	18.		9.	14.
10,000	3000		15.	22.		11.	16.
20,000	3700		18.	26.		12.	18.
40,000	4500		20.	30.		14.	21.
70,000	5800		25.	37.		17.	25.
100,000	7200		30.	45.		20.	30.

Cubic Space in Box or Room	Cubic Foot per Ton Ref.	Temperature 20°F					
		Direct Exp.			Brine ‡		
		1-in.	1¼-in.	2-in.	1-in.	1¼-in.	2-in.
12	113	1.6	2.2		1.4	2.	
20	137	1.7	2.3		1.4	2.	
50	160	1.8	2.4		1.5	2.1	
100	205	2.	2.6		1.6	2.2	
250	348		2.8			2.4	
500	580		3.2			2.7	
1,000	820		3.8	5.5		3.	4.
3,000	1100		4.5	6.5		3.4	4.5
5,000	1600		6.	8.		4.	5.5
10,000	2100		7.	10.		4.7	6.5
20,000	2600		8.	12.		5.5	7.5
40,000	3200		9.	14.		6.5	8.5
70,000	4000		11.	17.		7.5	10.
100,000	4900		14.	20.		9.	12.

Mean Temp. Ammonia Expansion 0°F.

" " Brine in Coils *5°, ‡10°F. & †15°.

Tables based on continuous operation 24 hours per day. If Ammo. is expanded half the time use equal length of pipe in brine tank and double the tonnage.

Tonnage and Piping Tables

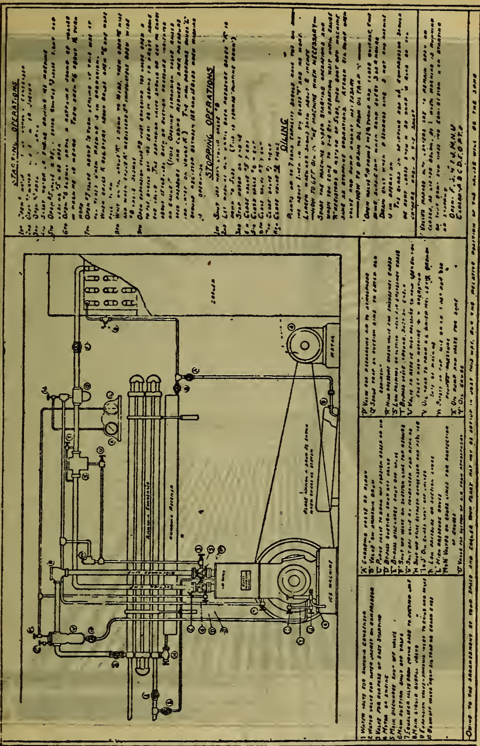
Cu. Ft. Space to 1 Ft. of Pipe

Cubic Space in Box or Room	Cubic Foot per Ton Ref.	Temperature 30°F					
		Direct Exp.			Brine †		
		1-in.	1¼-in.	2-in.	1-in.	1¼-in.	2-in.
12	130	2.3	3.5		2.	2.8	
20	159	2.4	3.6		2.	2.9	
50	200	2.5	3.7		2.1	3.	
100	260	2.7	3.9		2.2	3.1	
250	430		4.5			3.4	
500	710		5.4			4.	
1,000	1000		6.5			4.5	7.
3,000	1300		7.5	10.		5.	8.
5,000	1900		9.	12.		6.	9.
10,000	2600		11.	15.		7.	11.
20,000	3100		13.	17.		8.	12.
40,000	3700		15.	20.		10.	14.
70,000	4800		18.	24.		12.	17.
100,000	6000		20.	28.		14.	20.

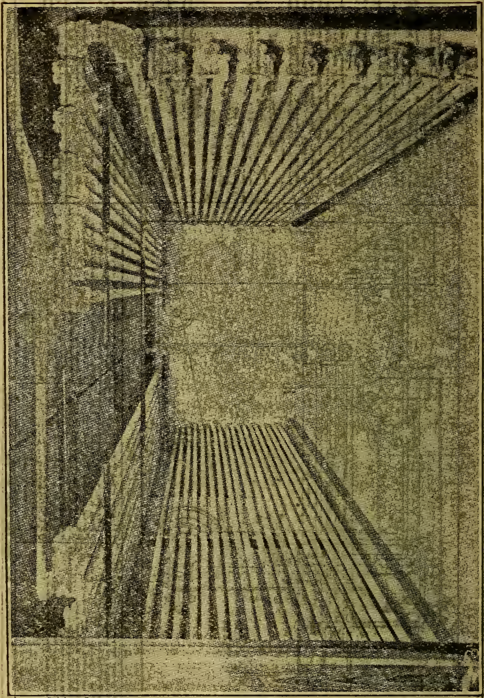
Cubic Space in Box or Room	Cubic Foot per Ton Ref.	Temperature 10°F					
		Direct Exp.			Brine *		
		1-in.	1¼-in.	2-in.	1-in.	1¼-in.	2-in.
12	93	1.	1.2		.6	1.1	
20	112	1.	1.2		.6	1.1	
50	130	1.1	1.2		.6	1.1	
100	168	1.2	1.3		.6	1.2	
250	280		1.4			1.3	
500	470		1.6	2.5		1.5	
1,000	650		2.2	3.		1.7	2.3
3,000	840		2.5	3.6		1.9	2.6
5,000	1140		3.2	4.6		2.2	3.3
10,000	1600		4.	5.7		2.6	4.
20,000	2100		4.8	6.8		3.	4.7
40,000	2600		5.5	8.		3.5	5.5
70,000	3100		6.5	10.		4.2	6.7
100,000	3800		8.	12.		5.	8.

Mean Temp. Ammonia Expansion 0°F.
" " Brine in Coils *5°, ‡10°F. & †15°

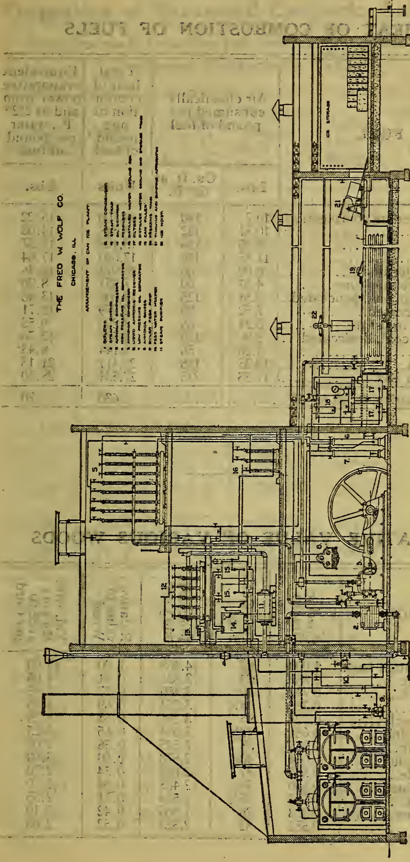
Tables based on continuous operation 24 hours per day. If Ammo. is expanded half the time use equal length of pipe in brine tank and double the tonnage.



THE BAKER MACHINE
The Most Economical and Efficient Machine Made for
Medium Plants, Capacity from 2 to 25 Tons



The proper way to pipe a cold storage for storing artificial ice



An up-to-date ice making plant. Very handy lay out.

HEAT OF COMBUSTION OF FUELS

FUEL	Air chemically consumed per pound of fuel		Total heat of combustion of one pound of fuel	Equivalent evaporative power from and at 212° F., water per pound of fuel
	Lbs.	Cu. ft. at 62° F.	Units	Lbs.
Coal of average composition	10.7	140	14,700	15.22
Coke	10.81	142	13,548	14.02
Lignite	8.85	116	13,108	13.57
Asphalt	11.85	156	17,040	17.64
Wood desiccated	6.09	80	10,974	11.36
Wood, 25% moisture	4.57	60	7,951	8.20
Wood, charcoal, desiccated	9.51	125	13,006	13.46
Peat, desiccated	7 52	99	12,279	12.71
Peat, 30% moisture	5.24	69	8,260	9.53
Peat, charcoal, desiccated	9.9	130	12,325	12.76
Straw	4.26	56	8,144	8.43
Petroleum	10.33	188	20,411	21.13
Petroleum oils	17.33	235	27,531	28.50
Coal gas per cu. ft. at 62° F.	....	....	630	.70

RELATIVE VALUE OF VARIOUS WOODS

WOOD	Specific Gravity	One Cubic Foot	Pounds in one Cord	Relative value of Wood	Val. with Hickory at $5.00 per Cord
Hickory Shell bark	1.000	62	4,469	1.00	$5.00
White Oak	0.885	53	3,821	0.81	4.05
White Ash	0.772	49	3,450	0.77	3.85
Red Oak	0.728	45½	3,254	0.69	4.45
White Beech	0.724	45	3,236	0.65	3.25
Black Walnut	0.681	42½	3,044	0.65	3.25
Red Cedar	0.665	35	2,525	0.56	2.08
Hard Maple	0.644	40	2,878	0.60	3.00
Soft Maple	0.597	37	2,668	0.54	2.70
Yellow Pine	0.550	34	2,463	0.54	2.70
Butternut	0.567	35½	2,534	0.51	2.55
White Pine	0.418	26	1,866	0.42	2.10
Chestnut	0.552	32	2,333	0.52	2.60

Properties of Saturated Carbonic Acid Gas

Transformed into United States Measures from Professor Schroeter's Table

Temp. Fahrenh.	Press. Atm.	Total Heat B. T. U. Above 32°	Heat of Liquid B. T. U. Above 32°	Latent Heat of Evapor	Weight of Vapor Lbs. per cu. ft.
80	68.0	104.0	63.0	41.0	17.5
70	60.5	103.9	44.0	60.0	13.1
60	52.5	103.6	29.4	74.0	10.6
50	46.2	103.2	17.6	85.6	8.7
40	40.0	102.8	7.5	95.0	7.0
30	34.5	102.2	—1.8	104.0	5.9
20	29.5	101.6	—10.0	111.0	5.0
10	25.0	100.9	—17.5	118.0	4.17
0	21.2	100.3	—24.0	124.0	3.5
—10	17.7	99.5	—30.9	130.0	2.9
—20	14.8	98.5	—36.5	134.0	2.45
—30	12.4	97.5	—41.5	140.0	2.0

Gallons of Ice Water Cooled per Hour	Floor Space Required in Feet		Capacity Plant Required Tons Ref.	Index Number
	A	B		
50	10	8	1½	AW
125	10	10	4	BW
200	15	14	6	CW
300	20	18	10	DW
400	20	22	14	EW

RULES FOR SPRINKLING SYSTEM

WATER SUPPLIES.

Double Supply.—Two independent supplies are absolutely necessary for a standard equipment. At least one of the supplies to be automatic and one to be capable of furnishing water under heavy pressure. The choice of water supplies for each equipment to be determined by the Underwriters having jurisdiction.

Size of Connection.—Connection from water supply or main pipe system to sprinkler riser to be equal to or larger in size than the riser.

PUBLIC WATER WORKS SYSTEM.

(Rules also applicable to private reservoir and stand pipe systems.)

1. Pressure Required.—Should give not less than 25 pounds static pressure at all hours of the day at highest line of sprinklers.

Where the normal static pressure complies with the above, the supply to be also satisfactory to the Underwriters having jurisdiction, in its ability to maintain 10 pounds pressure at highest sprinklers, with the water flowing through the number of sprinklers judged liable to be opened by fire at any one time.

Size of Mains.—Street mains should be of ample size, in no case smaller than 6 inches.

Dead Ends.—If possible, avoid a dead end in street main by arranging main to be fed at both ends.

Meter.—No water supply for sprinklers to pass through a meter or pressure regulating valve, except by special consent.

STEAM PUMP.

Type.—To be in accordance with the National Standard specifications.

Capacity.—To be determined by Underwriters having jurisdiction in each instance, but never less than 500 gallons rated capacity per minute.

8. Pump for Filling.—It is desirable to have water fed to tank by a pump so that proper water level may be restored at any time without reducing air pressure.

3. **Risers and Feed Mains.**—Central feed risers:
1½ inch. Not over 6 heads.
2 inch. Not over 10 heads.
2½ inch. Not over 20 heads.
3 inch. Not over 36 heads.
3½ inch. Not over 55 heads.
4 inch. Not over 72 heads.

For gridiron side feed risers, use the same sizes counting to the center of each line. If number on line is odd the center head may be neglected in figuring size of side risers except that pipe feeding both risers must take into account all sprinklers which it feeds. Where feed main (including risers to the first branch line) is over twenty-five feet in length feed main to be at least a size larger than the tables require. Where there is more than one riser size of feed mains to be determined by the Underwriters having jurisdiction but never to be less than the full equivalent of the two largest risers.

11. **Drip Pipes.**—Drip pipes to be provided to drain all parts of the system. Drip pipes at main risers to be not smaller than two (2) inches, and when exposed to the weather to be fitted with hood or down-turned elbow to prevent stoppage with ice.

12. **Drainage.**—All sprinkler pipe and fittings to be so installed that they can be thoroughly drained, and, where practicable, all piping to be arranged to drain at the main drips. On wet pipe systems the horizontal branch pipes to be pitched not less than ¼ inch in 10 feet. (See also Sec. H 2.)

12. **Exhaust Pipe.**—Each pump to be provided with an independent exhaust pipe, free from liability to back pressure and equipped with an open drain pipe at lowest point.

13. **Steam Pressures.**—Steam pressure of not less than 50 pounds to be maintained at the pump at all times.

14. **Boilers.**—Provision to be made for sufficient steam power to run pump to full rated capacity; not less than 40 H. P. for each 250 gallons rated capacity of pump. Boilers to be supplied with ample water supply not liable to be crippled in case of fire. Where forced draught is necessary, provisions should be made for safe, independent control of the same.

(d) Heating: Where there is exposure to cold, tank to be provided with a steam coil inside and at the bottom. Coil to be made of brass or galvanized iron to prevent rusting and provided with a return pipe to the boiler room, or, tank to be provided with a direct steam pipe from boilers discharging into water near top and fitted with a check valve and perforated fitting to prevent siphoning.

2. **Hydrant Mains.**—No. 4-inch pipe to be used.

3. **For Pipes Extending to a Dead End:**—

a. Allow 200 feet 6-inch pipe with one 3-way hydrant.

b. Allow 500 feet 6-inch pipe with one 2-way hydrant.

This might be extended in special cases.

c. Allow 1,000 feet 8-inch pipe with one 3-way hydrant.

d. Allow 500 feet 8-inch pipe with one 4-way hydrant or its equivalent in hose streams.

e. Allow 300 feet 8-inch pipe to first hydrant, where there is a hydrant equivalent of 6 streams.

SECTION S—MISCELLANEOUS RULES.

1. **Circulation in Pipes.**—Circulation of water in sprinkler pipes is very objectionable, owing to greatly increased corrosion, deposit of sediment and condensation drip from pipes; sprinkler pipes not to be used in any way for domestic service.

Location.—To be so located on the premises as to be free from damage by fire or other cause. Pump room should be readily accessible and provide easy and safe egress for attendant.

PRESSURE TANK.

Capacity.—Total capacity of tank to be specified by Underwriters having jurisdiction, but not less than 4,500 gallons, except by special permission.

Location.—Tank not to be located below upper story of building.

Tank Service.—Tanks to be used as a supply to automatic sprinklers and hand hose only.

Capacity.—Total capacity of tank to be specified by Underwriters having jurisdiction, but not less than 4,500 gallons, except by special permission.

Location.—Tank not to be located below upper story of building.

GRAVITY TANK.

1. **Capacity.**—To be specified by the Underwriters having jurisdiction. In no case to be of less than 5,000 gallons capacity.

Capacity of the tank to be computed from the net depth measured from the top of the discharge pipe to bottom of overflow pipe.

2. **Elevation.**—Elevation of bottom of tank above highest line of sprinklers on system which it supplies to be specified by the Underwriters having jurisdiction. The greater the elevation of a gravity tank the less likelihood of inefficient service. Underwriters having jurisdiction are urged to have such tanks placed at the greatest practicable elevation.

3. **Tank Service.**—Tank to be used as a supply to automatic sprinkler system only, except that, at the discretion of the Underwriters, tank may be made larger than called for, and so arranged that the excess supply only may be used for other purposes.

4. **Independent Drain.**—Provision to be made to drain each tank independently of other tanks and the sprinkler system. The practice of placing drain valves at lower levels and accessible from the exterior of buildings is not approved.

5. **Test.**—Tank to be tested and proved tight at a hydrostatic pressure of at least 25 per cent. in excess of the normal working pressure required. Water then to be drawn off to the two-thirds line and tank tested at the working air pressure required. In this condition and with all valves closed, tank not to show loss of pressure in excess of ½ pound in 24 hours.

6. **Fittings and Connections.**—(a). Gage Glass: To be placed on the end of horizontal and side of upright tank so that the two-thirds line will be at the center of the glass. Gage glass valves to be of the best quality angle globe pattern.

The two valves in the water gage connections to be kept closed and opened only to ascertain the amount of water in the tanks; as breaking of or leakage about glass will cause the escape of pressure.

SECTION P—STEAMER CONNECTIONS.

1. **Recommendations.**—In addition to the above required double supply, it is recommended that a hose inlet pipe to sprinkler system be provided for connection from hose or steamer of public fire department.

2. **Pipe Size.**—To be not less than four (4) inches in size and fitted with a straightway check valve, but not with a gate valve. Siamese connections to be provided with check valves in the "Y."

A ¾-inch drip pipe and valve to be installed so as to properly drain the piping between the check valve and the outside hose coupling.

Connections to be so located as to provide for prompt and easy attachment of hose.

3. **Where Attached.**—To equipments having a single riser, attach on the system side of the gate valve in the riser if a wet system, but on the supply side if the dry valve if a dry system.

To equipments having two or more risers, attach on the supply side of the gate valves, so that with any one riser shut off the supply will feed all the remaining sprinklers.

4. **Threads.**—Each hose connection to be made of good brass, having thread to fit coupling of public fire department. Malleable iron or brass caps, secured to connection by chains and having suitable lugs at sides to fit spanner wrench of public fire department, to be provided for each connection.

Each hose connection to be designated by raised letters at least 1 inch in size, cast in the fitting in a clear and prominent manner, and reading: "Auto. spkr."

2. **Painting and Bronzing.**—Where pipes are painted or bronzed for appearance, the moving parts of sprinkler heads should not be so coated.

3. **Piling of Stock.**—Sprinkler heads to be free to form an unbroken spray blanket for at least 2 feet under the ceiling from sprinkler to sprinkler and sides of room. Any stock piles, racks or other obstructions interfering with such action are not permissible.

4. **Settling of Building.**—Where a building settles and deprives a dry pipe system of its drainage, the ends of lines should not be raised to violate Sec. B, 3. The drainage should be restored by shortening the vertical piping.

5. **Position of Deflector.**—Notice that it is the deflector of a sprinkler which should be at least 3 inches (and not over 10 inches) from ceiling or bottom of joists; 6 to 8 inches is the best distance with average pressure and present types of sprinklers. (See Sec. B, 3.)

6. **Hanging Stock to Piping.**—Sprinkler piping should not be used for the support of stock, clothing, etc.

7. **Alterations.**—It is not permitted to change, plug up or remove the fittings pertaining to dry pipe valve, pressure tanks, pumps, gages, etc. If such fittings leak or become deranged, they are to be put in order.

8. **Extra Sprinklers.**—There should be maintained on the premises a supply of extra sprinklers (never less than six), to promptly replace any fused by fire or in any way injured.

9. **Use of High Degree or Hard Sprinklers.**—High degree sprinklers should be used only when absolutely necessary. When used, the fusing points should be as low as the conditions will safely permit. Underwriters having jurisdiction should be consulted in each instance before the installation of high degree sprinklers.

Ordinary degree sprinklers should be substituted for high degree sprinklers where the latter are made unnecessary by change in occupancy.

10. **Hand Hose Connections.**—Hand hose to be used for fire purposes only, may be attached to sprinkler pipes within a room under the following restrictions:

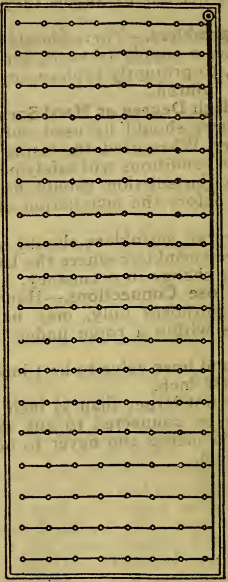
Pipe nipple and hose valve to be 1 inch.

Hose to be 1¼ inch.

Nozzle to be not larger than ½ inch.

Hose not to be connected to any sprinkler pipe smaller than 2½ inches and never to be attached to a dry pipe system.

General Plan Sprinkler Equipment



End Side-Feed to Automatic Sprinklers.
UNAPPROVED

• shows a Sprinkler. ◎ shows a Riser.

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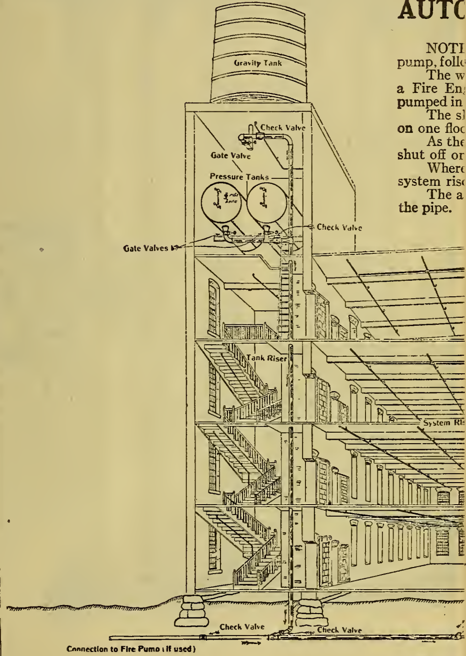
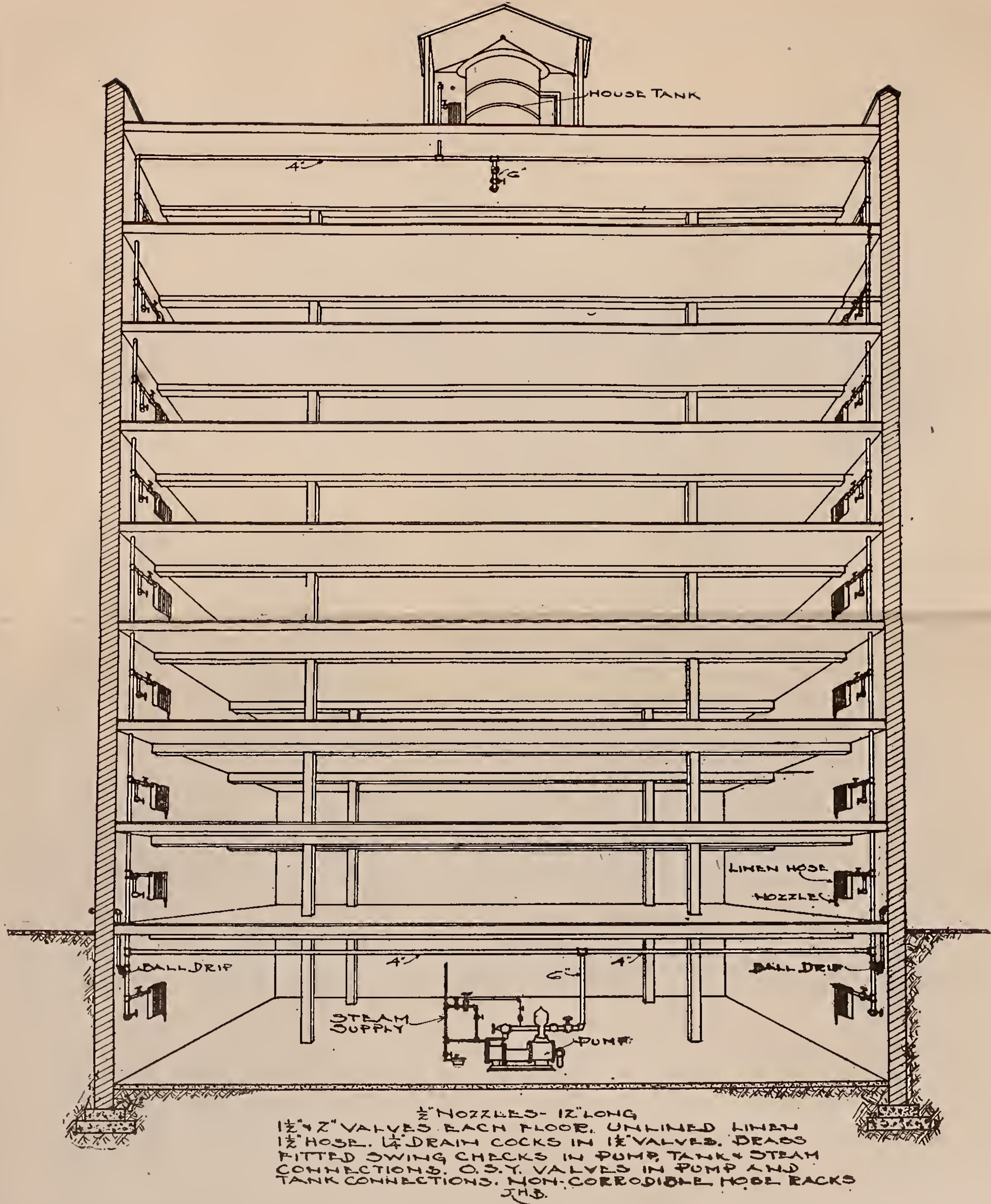


Arrows Show Direct


HOUSE TANK
4"
6"
LINEN HOSE
NOZZLE
BALL DRIP
BALL DRIP
4"
6"
4"
STEAM SUPPLY
PUMP
½" NOZZLES - 12" LONG
1½" & 2" VALVES EACH FLOOR. UNLINED LINEN
1½" HOSE. 1¼" DRAIN COCKS IN 1½" VALVES. BRASS
FITTED SWING CHECKS IN PUMP, TANK & STEAM
CONNECTIONS. O.S.Y. VALVES IN PUMP AND
TANK CONNECTIONS. NON-CORRODIBLE HOSE RACKS
J.H.B.

TYPICAL ARRANGEMENTS

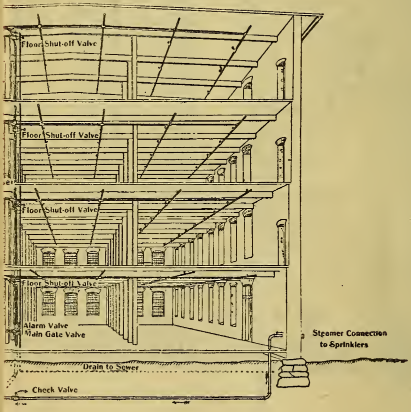
OF

R SUPPLIES, CONNECTIONS AND VALVES

FOR

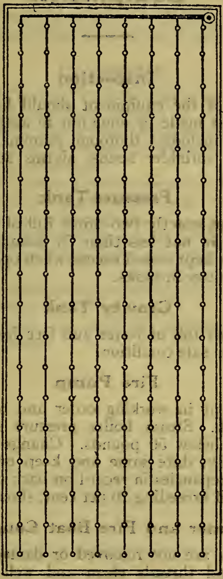
MATIC SPRINKLER EQUIPMENTS

:—The initial source of water supply is from the pressure tanks, or fire
wed by water from the gravity tank in case the other sources are exhausted.
ater can only flow in the direction of the open sprinklers, therefore, should
gine be connected to the steamer connection for sprinklers, and water
to the underground main, the water would go direct to the open sprinklers.
ut-off valves on each floor are for the purpose of shutting off the water
r and leaving the balance of building under protection.
re may be more than one riser in the building care should be observed to
ly the system in operation.
the system is without floor shut-off valves, the main valve at base of
r must be closed to control the water.
larm valve at base of system riser gives alarm when water flows through



ion of Water Flow

General Plan Sprinkler Equipment



Across End Feed to Automatic Sprinklers-Long Lines.
UNAPPROVED
o shows a Sprinkler; ⊙ shows a Riser.

TYPICAL ARRANGEMENTS
OF
WATER SUPPLIES, CONNECTIONS AND VALVES
FOR
AUTOMATIC SPRINKLER EQUIPMENTS

NOTE:—The initial source of water supply is from the pressure tanks, or fire pump, followed by water from the gravity tank in case the other sources are exhausted.

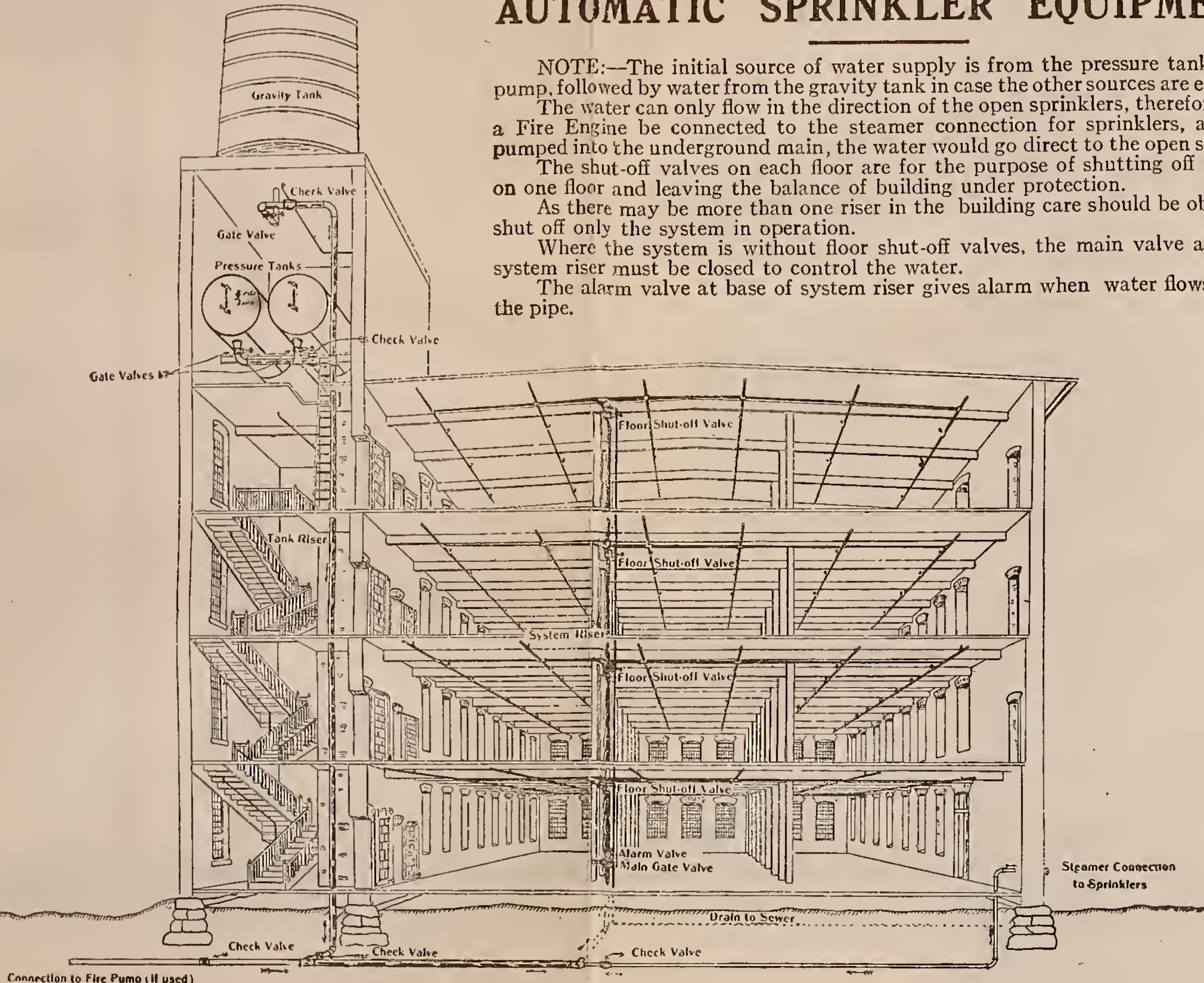
The water can only flow in the direction of the open sprinklers, therefore, should a Fire Engine be connected to the steamer connection for sprinklers, and water pumped into the underground main, the water would go direct to the open sprinklers.

The shut-off valves on each floor are for the purpose of shutting off the water on one floor and leaving the balance of building under protection.

As there may be more than one riser in the building care should be observed to shut off only the system in operation.

Where the system is without floor shut-off valves, the main valve at base of system riser must be closed to control the water.

The alarm valve at base of system riser gives alarm when water flows through the pipe.



Arrows Show Direction of Water Flow

Pertaining to the Care of Sprinkler Equipments

Inspection

All portions of the equipment should be inspected each day and a report made to some one in authority. Such inspection should include a thorough examination of all tanks, pumps, valves, sprinkler heads, alarms and couplings for city department.

Pressure Tank

Should be kept exactly two-thirds full of water and under an air pressure of not less than 75 pounds. Water gauge valves should be kept closed except when opened to ascertain the amount of water in tanks.

Gravity Tank

Should be kept full of water and free from ice. Ladders should be kept in safe condition.

Fire Pump

Should be kept in working order and operated at least once each week. Steam boiler pressure should never be allowed to fall below 50 pounds. Change recording steam gauge dials daily, date same and keep on file, noting all reasons for discrepancies in record on back of dial. Internal leakage or slip, if exceeding 10 per cent, should be eliminated

Steamer and Fire Boat Couplings

See that they are not removed or damaged in any way. Keep swivel and threads clean and well lubricated with graphite and oil.

Valves

Make sure that all valves are open. It is desirable to seal them open with light half-inch leather straps and small brass padlocks. Wet system alarm contacts and dry valve contacts should be kept clean and properly adjusted. Maintain an air pressure of not less than 25 pounds nor more than

40 pounds on dry pipe valves. Make certain that dry system is thoroughly drained before it is set up dry. Set valve in absolute accordance with instructions accompanying valve.

Alarms

Should be tested at least twice each week. See that batteries are well charged and that wiring is in good condition.

In General

All stock should be kept 12 inches below sprinkler piping.

Uprights, ceiling blocking, hangers or other obstructions, should not be placed nearer than 12 inches to sprinkler heads.

Piping should not be raised in hangers to avoid belts, pulleys, or other interferences.

Sprinkler heads should never be covered with paint or whitewash; they should be carefully protected with small paper bags when decorating is being done.

Replace all corroded heads with new heads.

Keep all heads free from large accumulation of dirt and dust.

Keep an extra supply, one or two dozen, of sprinkler heads on hand at all times.

When extra heads are installed, maintain the following standard for pipe sizes:

No. of Heads	Pipe Sizes in Inches.
1	¾
2	1
3	1¼
5	1½
10	2
20	2½
36	3
55	3½
80	4
140	5
200	6

Difference in temperature between outside air and air in room, in degrees F.

Be sure to replace all sprinklers, or lines of sprinklers, that have been removed. This fault has caused many serious losses.

Decks or galleries should not exceed 30 inches in width unless sprinkler protection is provided for under side of same. If a gallery or deck 30 inches wide is placed against a wall or partition, a 6-inch clearance should be maintained, and the back of the gallery or deck should be framed in to keep stock clear of the opening.

Do not build fixtures over 5 feet in width. Fixtures over 30 inches in width should be bulkheaded with tight partitions; compartments should not exceed 5 feet deep, 8 feet long and 3 feet high.

Tables more than 30 inches in width and less than 5½ feet in width, under which stock is stored, should be provided with tight upright partitions not exceeding 8 feet on centers; tables wider than 5½ feet should be provided with sprinkler protection underneath.

Never install more than 500 heads on one dry system, because it takes too long for air to clear out of system and allow valve to trip.

Curtain boards, 12 inches deep, should be placed around all open floor openings; this construction will bank the heat on the ceiling.

When an alarm rings in, do not shut a sprinkler valve until the cause of the alarm is definitely ascertained.

When a partition extending to ceiling is erected, it should be located midway between sprinkler lines and heads; if off center, install extra heads necessary to cover properly.

Never gag a dry valve because of leak; hunt the leak and repair it immediately. Often the leaving of water in a dry system a day or two during warm weather will rust up small leaks.

Do not wait for a fire to discover defects which may exist in your protective devices. Give the system careful attention and it may reasonably be expected to perform efficient service.

Filtration Plants.

It is sometimes thought that the chief reason for installing filters is to protect the health of those using the water for drinking purposes. Most filters installed in residences, apartment buildings, hotels and similar buildings are either installed for the purpose of cleanliness or to protect the plumbing system, or both. Where a water supply is turbid or contains floating particles of any kind, there is continuous trouble with valves, cocks, etc. Where the water is very bad, lines may even become stopped up. All this is entirely prevented by filtration. At the same time there is no piece of equipment put into a building where people live that gives more satisfaction than a filter by insuring at all times a supply of clear, clean, bright water.

Filters can be obtained in sizes from that suitable for a small dwelling up to any capacity to take care

of the largest building. Filters are not difficult to install, but there are certain precautions that should always be taken. The first thing to be considered is the selection of a proper size filter. Sometimes this is done by taking meter readings over a period of a month and averaging this to find how much water is used per hour. This is not a proper way because the use of water in any such building is never uniform. On the contrary, there are periods when almost no water is used, and other periods when the consumption is very high. The filter should be selected with a view to having capacity to take care of the maximum flow.

The filter may be located in any convenient place. The supply line to the sill cocks should be taken off before the filter, as there is no use of filtering water used for sprinkling lawns and such purposes. All water used inside the building should, however, pass through the filter. The only satisfactory type of filter for such service is the sand filter, and this type of filter will give excellent service for years without any repairs or renewals if properly installed and taken care of. The smaller capacities of filters are usually constructed with a cast iron shell as shown in illustration A. In the larger capacities the shell is commonly of steel as shown in illustration B. Under certain conditions the desired capacity should not be installed in a single unit, but there should be provided a battery of three units as shown in illustration C. Particular consideration should be given to determine whether one or three units is desirable in each case. There are several causes that may make an installation of three units preferable or necessary. One is that of space. Frequently it is necessary to install filters in a narrow passageway where a battery of three can be placed along the wall easily, whereas a single unit would be too large and would close the passage. Again, there must be considered cleaning the filter. In the sand filter this is done by reversing the flow of water.

When the filter is filtering the water enters at the top and passes down through the bed of sand, the mud or other suspended impurities being retained on top of the sand. At certain intervals, or when the filter becomes clogged with accumulated sediment, this must be removed, which is done as mentioned above by reversing the flow of water. When washing the water enters at the bottom of the filter, passes up through the sand bed and overflows at the top, carrying with it

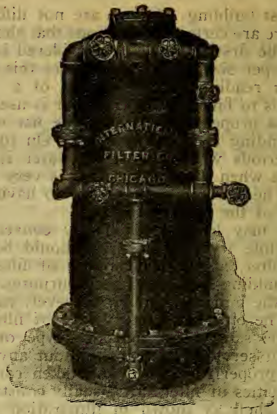


Illustration A

the mud or other material removed. It is necessary when the filter is being washed to have a stronger flow of water than the filter will handle when filtering. If the wash flow is not sufficient the sand bed will not be thoroughly loosened up and scoured out. In good practice the flow when washing must be three times that when filtering; consequently when the supply line is only large enough to carry the required flow when filtering, it is necessary to install the filter in three units so they can be washed one at a time. In many cases the water being filtered is so muddy or otherwise so bad that if used in its raw condition for washing, dirt would be left all through the filter bed. To meet this condition filters are installed in a battery of three as shown in illustration C. With this installation water can be drawn through any two filters to wash the third, which is thus perfectly cleansed with filtered water.

The inlet, outlet and waste openings of the filter are marked in the illustration. The waste line must always be carried full size to sewer. If this waste discharge is restricted it will interfere with proper washing of the filter. For the same reason this waste discharge should be as short and straight as possible.

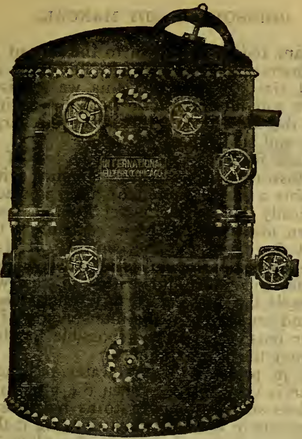


Illustration B

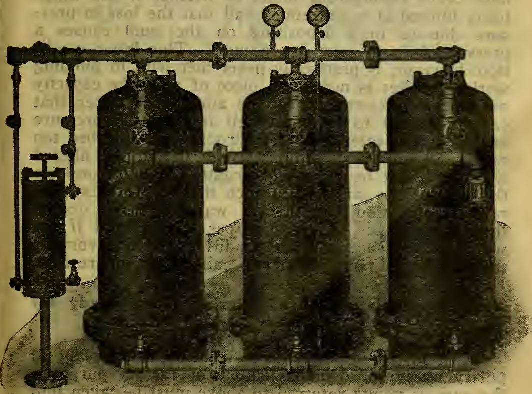


Illustration C

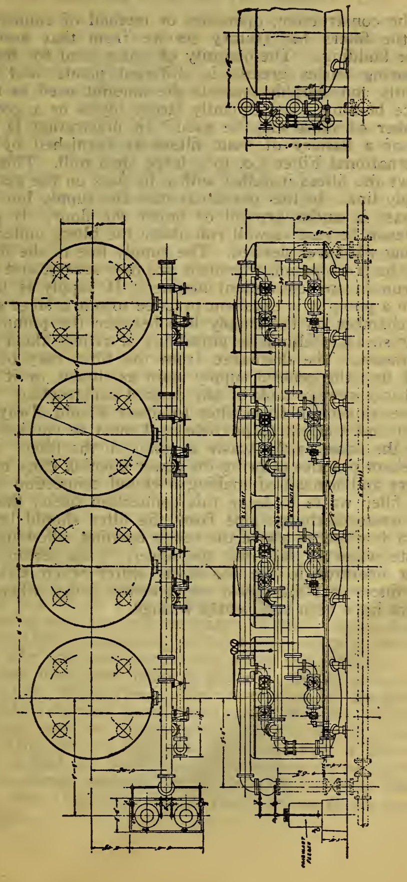
A coagulant feeder as shown to the left of the three filters in illustration C. The waste line must always be carried full size to sewer. If this waste discharge is restricted it will interfere with proper washing of the filter. For the same reason this waste discharge should be as short and straight as possible.

A coagulant feeder as shown to the left of the three filters in illustration C, is always supplied with a sand filter. In this a small amount of alum is placed which is automatically fed to the water. Some people have the mistaken idea that this alum remains in the water. This is not the case. On the contrary, if it remained in the water it would not do its intended work. It acts on the mud and other impurities in the water and separates itself out in solid form so that it is removed with the mud remaining in the filter on top of the sand. In many or most cases it is impossible to obtain clear water without the use of alum.

The loss in pressure of the water passing through a sand filter is very small. When the filter is perfectly clean this loss seldom amounts to as much as a pound. As mud deposits in the filter thus clogging it this loss in head increases. In good practice the filter is washed once every twenty-four hours or oftener if the water being filtered is so extremely bad that the loss in pressure due to mud depositing on the sand causes a pressure drop of over five pounds. This latter condition, however, is practically never met with in building work. A filter is not like a piece of pipe, the capacity of which is determined by the amount of water that can be forced to flow through it with the pressure available. If water is forced through the sand bed too rapidly it will carry sediment with it and the filtered water will not be clear and bright. In good practice the area of the sand bed is such that at the maximum rate of operation the flow of water will not exceed three gallons per square foot per minute, and if the water is very bad, or other conditions are unfavorable, the rate should not be over two gallons per square foot.

Typical Installation of a Filtering Plant Ready for Pump Connections.

When installing filters in a manufacturing plant to purify water for drinking supply or factory purposes, the various points referred to above must be taken into consideration in the same way. There is no difference



Layout of Filtering Plant

in the construction, operation or method of connecting up the filters for factory service from that used in other buildings. The quantity of water used for manufacturing varies greatly in different plants, and frequently considerably exceeds the amount used in residence buildings, consequently larger filters or a greater number of units may be used. In illustration D is a cut of a battery of four filters as furnished by the International Filter Co. to a large steel mill. This cut shows the filters installed with a by-pass on the general supply line. In this particular case the supply line and by-pass is under ground or under the floor. It may, however, be just as well run above the filters under the ceiling whenever desired. The supply line to the filters may be from pump, city main or other source, and may be run in any convenient manner. If supply is taken from a pump it is excellent practice to put a large sized air chamber on the supply line between the pump and filter so as to eliminate pulsations or reduce them to a minimum. The discharge from the filter may be led back into the general supply main as shown, or it may lead to a storage tank of any desired construction. The waste connection from filter to sewer should always be short and straight as possible, and must be carried full size the same as the waste opening on the filter. It is excellent practice to bring the sewer opening close to the filters and instead of making a closed connection from the filter waste to leave this connection open; that is, the waste discharge pipe from the filter should be cut off a few inches above the sewer opening, allowing the waste water to fall into the sewer. This permits the filter operator to see the waste water when washing the filters and thus most conveniently judge when the filters have been sufficiently washed.

Refrigerating Machines for Domestic Use

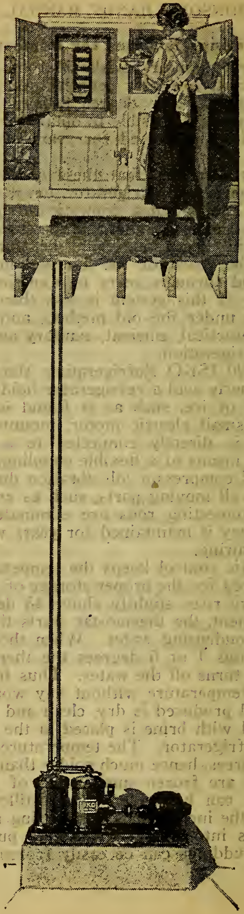
Proper preservation of perishable food products requires a constant, low, dry temperature, readily controlled, and held at any degree desired. Mechanical refrigeration makes it possible to obtain all these points, and has therefore been used for years in cold storage plants.

It is just as necessary that these qualities be maintained in the household refrigerator, but it was not until the advent of ISKO that a domestic refrigerating machine, which is foolproof, thoroughly reliable, quiet and automatic in its operation, could be purchased at a price within the reach of the average household. It has been found through years of experience that the operating cost of this system is less than the cost of the ice melted under the old method, and is therefore a thoroughly practical, efficient, sanitary and convenient method of refrigeration.

The Model 20 ISKO Refrigerating Machine is large enough to properly cool a refrigerator holding from 250 to 300 pounds of ice, such as is found in an average residence. A small electric motor, mounted on a suspension base, is directly connected to a rotary gear compressor by means of a flexible coupling. By the use of this type of compressor all vibration due to reciprocating motion, all moving parts, such as cranks, valves, pistons and connecting rods are eliminated, thus this original efficiency is maintained for years without overhauling or repairing.

The automatic control keeps the temperatures within the limits desired for the proper storage of food. When the temperature rises slightly above 45 degrees in the food compartment, the thermostat starts the motor and turns on the condensing water. When the temperature in the box drops 4 or 5 degrees the thermostat stops the motor and turns off the water. Thus foods are kept at a uniform temperature without any worry or attention. The cold produced is dry, clean and sanitary.

A tank filled with brine is placed in the ice compartment of the refrigerator. The temperature of the brine is about 20 degrees, hence much colder than ice. Within the brine tank are frozen small cubes of ice for table use. This ice can be made from distilled or filtered water so that the inconsistency of putting ice of uncertain cleanliness into water of absolute purity is done away with. Puddings can be easily frozen in the pans provided.



Home Refrigeration without Ice at Reasonable Cost

The machine is only 12 inches wide by 35 inches long and 18 inches high, and can be quickly and neatly installed on any refrigerator. It can be placed on top of the box, in an adjoining room or in the basement if desired. Every part has been carefully designed and tested at the factory. It is automatically controlled and requires an occasional inspection and oiling of bearings.

Motors can be furnished for every current specification so that if the electricity be supplied by the farm lighting or by public service system there is a machine to suit.

The refrigerant used is sulphur dioxide. This gas is not poisonous, nor inflammable, nor explosive, nor dangerous under any conditions. In regular operation the pressures do not exceed 60 pounds, so that the possibility of leaks is reduced to a minimum.

Liquid sulphur dioxide boils at 14.7 degrees F. As a gas it is frequently used as a disinfectant. When compressed to about 55, and at temperature of about 70 degrees F., it becomes a liquid. This liquid is supplied under pressure to the expansion coil in the brine tank. Here at about atmospheric pressure it expands to a gas producing a temperature of 15 degrees. Heat, which must be supplied to bring about this change of state from a liquid to a gas, is taken from the brine tank which surrounds the expansion coil. This transfer of heat from the brine to the cold gas continues until the machine is stopped. The brine being thus cooled acts as a storage for the refrigeration and keeps the temperature from fluctuating.

The expanding gas from the coils is forced into the condensing cylinder by the gear compressor; there the heat is absorbed by the cooling water. The gas returns to its liquid state ready to be supplied again to the expansion coils.

The only connections needed are easily and simply made. When possible a separate circuit from the cut out center should be run for ¼ H. P. motor, connecting automatic control panel, and the solenoid valve.

Water connections require ¼-inch iron pipe and fittings. As only 15 gallons of water per hour are necessary, a needle valve should be placed in the line to regulate the amount of water supplied to the condensor. From the water outlet elbow a line is carried to the sink or open drain.

A larger machine, the Model 200 ISKO, is suitable to the needs of the meat market, grocery, fruit store,

dairy, soda fountain, hospital, small hotel, restaurant, cafe, florist, town and country club, and factory and shop drinking water cooling system. It has a capacity of 2,000 lbs. of ice melting effect every twenty-four hours.

The construction of this larger machine is nearly identical with the smaller unit above described. Its operation is also automatically controlled by the thermostat, so that there is no fear that products will spoil over the week-end or holiday.

There are distributors for ISKO refrigerating machines established throughout the entire United States so that proper and careful installations can be assured and attentive inspection and service maintained. The engineers with these distributors are ready to properly design any system and give their advice on any refrigerating problem that may arise.

For household refrigerators holding 250 to 300 lbs.

Space cooled (well insulated), 25-40 cu. ft.

Approximate water consumption per hour, 12 gals.

Approximate motor input per hour (¼ H. P. motor), 35 Ow.

Dimensions of machine (not including brine tank): Length 35″, depth 12″, height 18″.

Weight (not including brine tank), net 250 lbs., gross 295 lbs.

Brine Tank Specifications.

Brine tanks, made in several sizes to fit various refrigerators, are sold as an integral part of ISKO and included in price stated, but specifications are separately listed below.

	Over-all Dimensions			Weight	
No.	Width	Depth	Height	Net	Gross
D-3	13"	12½"	20"	58 lbs.	80 lbs.
D-4	13"	14¾"	22"	70 lbs.	95 lbs.
D-5	14½"	16"	25½"	73 lbs.	102 lbs.

Refrigeration is constant and continuous, but the machine is operating only a part of the time, thus conserving the water and electric consumption.

The ISKO System is a direct connected electrical refrigerating machine. Uses a valveless gear compressor running on ball bearings and submerged in oil. Has only two moving parts, which eliminate cranks, pistons, rings, suction and discharge valve and similar parts subject to wear. Uses a low pressure, harmless refrigerant (sulphur dioxide), a non-inflammable, non-explosive gas. Its endurance has been established under a continuous run equivalent to fourteen years of actual service operation. Has been in general use in homes. markets and restaurants for four years. The ISKO System for house or commercial purposes can be inspected at any of our distributing centers in the larger cities throughout the United States.

The Ice Question.

Stop taking ice—get rid of the bother, dirt and uncertainty of delivered ice.

Get the really low temperatures that the cold storage man knows are necessary to keep food fit to safely eat.

Cut down the cost of maintaining the ice box to a fraction of the cost of uneconomical horse-drawn, man-handled delivered ice.

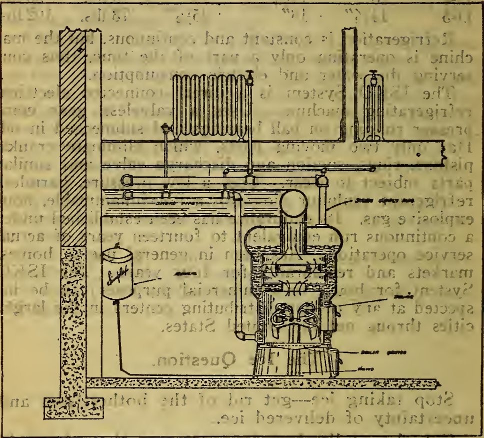
Keep your refrigerator so cold that it is always sweet and fresh as winter air.

Mould and moisture are half-brothers and both are the offspring of melting ice.

Changes your refrigerator from an ice-taking ice box into an ice-making refrigerator.

Heat and Cook with Kerosine Oil by Installing the

SIMPLEX OIL BURNER



Can be installed in your heating apparatus, parlor or cook stove without changing or disturbing the same. No ashes. No coal dust. No work. No odor.

Hydro-Carbon Gas for Your Furnaces

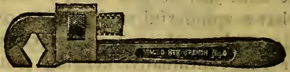
By installing the Simplex Oil Burner in your heater or furnace, you can produce any desired heat you require, at a much less cost than coal, and eliminate the handling of coal and ashes and kindling of fires. In mild weather you can start your burner in the morning, run it for two hours, heat your house, shut it off and you have all the heat you can use all day. Do the same thing in the evening and your house is sufficiently warm all night. The result is that you get all the heat you can use from four hours' fuel, a saving to you of twenty hours, where, with a coal fire, you must let it run continually or you have to re-kindle your fire, which is a dirty job, and you waste a lot of fuel. You can readily see by being able to light the fire and turn it out, getting the heat just as you want it and when you want it, what a wonderful saving oil is over the use of coal. In cold weather, if necessary, you can let the burner run continually, keeping your house at a much more even temperature than is possible with a coal fire, for the flow of oil is constant and the heat produced in the firepot is continuous and uniform.

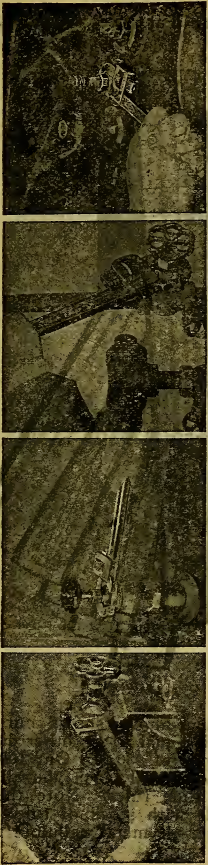
MY WRENCH.

My Wrench is the name of a new tool, a wrench to be used on hexagon nuts. You do not need to use a Stilsen or Trimo, or hammer and chisel to mar and chew up the nickel plated hexagon nuts, as you have done all your lifetime, just to make a tight joint. If you are a plumber or a fitter you will realize the great benefit and demand there is for a tool of this kind. My Wrench is a special tool used for hexagon nuts, and will not mar or chew the metal. Add a real tool to your kit.

Price and sizes below. By parcel post send money order for the amount. Address John W. Johnson, 850 Cass St., Chicago, Ill.

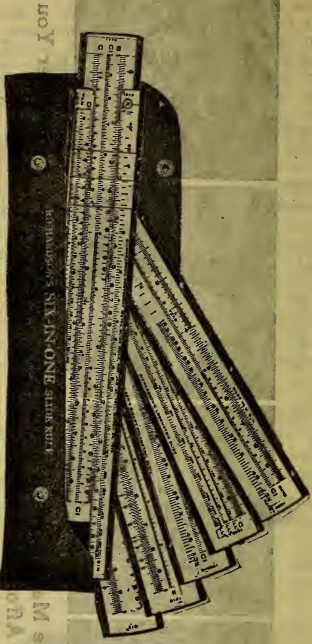
No.	Size of Hex Across Flats Inches	Length Open Inches	Length Closed Inches	Net Price, Each
0	½ to 1	8¼	7⅝	$1.45
1	¾ to $1\frac{7}{16}$	14	13	2.65
2	1½ to 2⅞	25	23	5.00





Illustrating the Many Uses of *My Wrench*. If You Are a Pipefitter You Can't Afford to Be Without It. No Tool Kit Is Complete Without This Wrench.

Richardson's Pantocrat Slide Rules

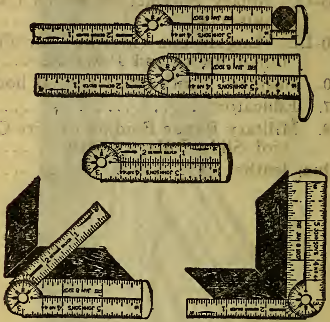


The cut showing above shows cur Six-in-One Slide Rule which is equal to six other different slide rules at a total price of $30.00. Our 100-page book, with 135 illustrations, will teach you all there is to be known about slide rules. Note the slides are all interchangeable with stock of rule. The above rules, 10 inch size, all metal celluloid faced scales

sold separately, if so desired. Order rules by number: Price each, net prepaid.

No. 812. Mannheim $3.00
No. 1812. Add and Subtracting............ 3.50
No. 1776. Polymetric CI Scale............... 3.50
No. 1865-O. Binary Polymeteric with CI scale Engineers 4.00
No. 1860-LL. Logometric (log-log) for Fractional Roots and Powers.......... 4.00
No. 1860. Business Man's, with special book.. 5.00
No. 1917. Educator 1.50
No. 1918. Military Range Finding or Fire Control Slide Rule, 18 inch...........20.00
Six-in-One, leather case......................... 10.00

Johnson's Patent Combination Pocket Rule



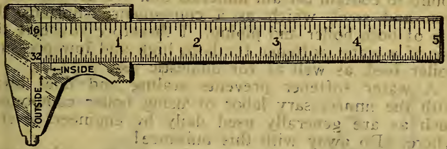
The Johnson Folding Pocket Rule is made of spring Liberty Silver, accurately and distinctly graduated. It can be used as a Square, Hook-rule, Caliper-gauge, Protractor, Triangle or Tri-square, and can be applied to practically all classes of mechanical work.

The upper edge is graduated in 32nds, the lower edge in 16ths. The Caliper blade is graduated in 16ths on one side and 32nds on the other. The Protractor is divided to five degrees and the Vernier to one-half degree.

Center joint has fibre bearings which will not become loose and will remain firm at any angle.
The illustrations on opposite page show only a few of the many uses this Rule is adapted to.

Price each, net Prepaid:
No. 46. 6 inch, with case....................**$2.00**
No. 45. 12 inch, with case.................... **3.00**

Combination Caliper



Inside Caliper, outside Caliper and Depth Gauge made of Spring Liberty Silver, guaranteed not to rust. No. 18 Gauge is used for the scale and No. 15 for the jaws which makes it light to carry in the pocket. One edge of the scale is graduated in 16ths and the other in 32nd. The jaws are 1 inch deep. The nibs can be inserted in holes ⅛ inch in diameter. The sliding jaw is supported with a friction spring which makes it the most practical tool of its kind. Price each net prepaid when remittance accompanies order.

No. 132.	4 inch	$3.00
No. 133.	5 inch	3.25
No. 134.	6 inch	3.50

The Use of Water Softeners

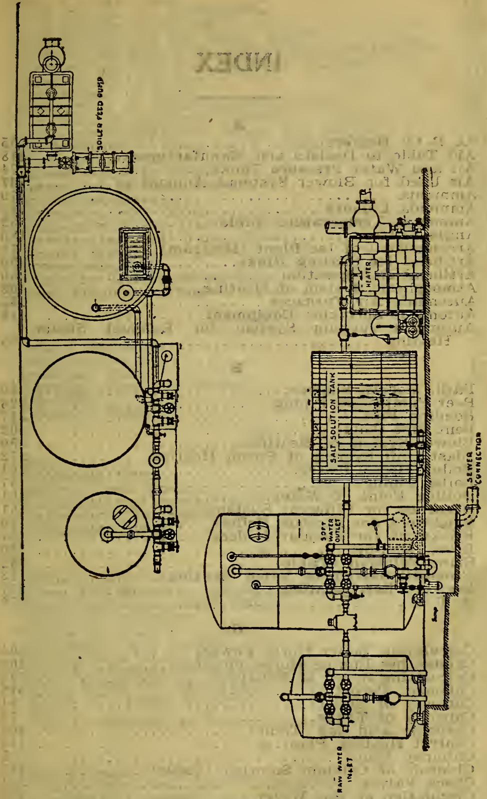
All mechanical engineers concede that hard water is a detriment to boilers and piping. When analyzed it is found to contain certain minerals that are destructive to iron and steel, which as a consequence shortens the life of both boiler and piping. I therefore advocate the use of a water softener for both high and low pressure boiler feed, as well as for domestic use.

A water softener prevents scaling and does away with the unnecessary labor of using boiler compounds such as are generally used daily by engineers everywhere. Do away with this nuisance!

Any engineer having anything to do with power plants where boilers are used can safely recommend a water softener of good type such as the "Permutit."

Boiler scale will not be found where soft water is used.

Make boiler washing a thing of the past by recommending a good softener.



Typical Layout of the "Permutit" Water Softener
Ready for Pump Connections

INDEX

D

E

F

G

H

I

J

L

M

T

U

V

W